Short Title: Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule.

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Proposal Summary:

The objective of this project is to improve National air quality management by developing a decision-support system (DSS) for the implementation of the new Exceptional Event (EE) Rule (Transition, 2007), which permits States to flag air quality (AQ) data caused by exceptional air pollution, such as forest fires and dust storms. The Rule requires States to provide evidence and quantify exceptional source contributions. Based on the reported evidence, EPA decides if the EE flag is justified.

Preparing and evaluating the EE evidence is a tedious, costly and technically challenging task for the State and EPA offices. A powerful EE DSS tool set will be developed that will allow users to (1) explore and analyze data for specific EEs (2) prepare EE flagging reports (3) evaluate and approve the EE reports. For the States, the powerful EE tools will make the event documentation easy and efficient, while for EPA, the standardized DSS tools will make the decisions more consistent and robust.

The project will achieve its goals primarily by linking, harmonizing and integrating and otherwise ‘connecting the pieces’ contributed by its autonomous core constituent partners represented by the projects GIOVANNI, NAAPS, VIEWS, AIRPACT and DataFed. The a wide range of distributed multi-sensory data (including MODIS, OMI, CALIPSO), suitably processed and packaged for the EE DSS using flexible web service orchestration. The EE DSS data browsing, processing, reporting and communication facilities will be combined and presented through a user-friendly EE DSS portal.

The broader benefits of this are project will include deeper scientific understanding of EEs and innovative application of remote sensing and information technologies to AQ regulatory processes. Building the EE DSS will also contribute to the creation of a persistent core network for supporting other AQ applications. The network will also exemplify multi-organization/agency collaboration using the principles and architecture of the Global Observing System of Systems.

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Decision-making Activities

The proposed DSS is aimed at improving the management of the Nation's air quality. The quality of ambient air is maintained at healthy levels by the setting and compliance with National Ambient air Quality Standards (NAAQS). In 2006, the NAAQS for PM2.5 was significantly revised by reducing the daily standard from 65 to 35 ug/m3 and recently for ozone from 85 to 75 ppb. Since the 2006 NAAQS amendments, both PM2.5 and ozone are subject to the new Exceptional Event (EE) Rule (Transition, 2007) which allows the exclusion of data strongly influenced by impacts from "exceptional events," such as smoke from a wildfire or dust from abnormally high winds. States may "flag" data for those days that they believe to be impacted by exceptional events. Such flagged days, if concurred with by EPA, may be given special consideration in the compliance calculations. The tightening of the short-term standards and the EE Rule shifts the attention from controlling the yearly average to the reduction and control of short-term, episodic air pollution events.

The EE Rule identifies different categories of uncontrollable events (Fig.1a): (a) Exceedances Due to Transported Pollution (Transported African, Asian Dust; Smoke from Mexican fires; Smoke & Dust from Mining, Agricultural Emissions) (b) Natural Events (Nat. Disasters.; High Wind Events; Wildland Fires; Stratospheric Ozone; Prescribed Fires) and (c) Chemical Spills and Industrial Accidents; Structural Fires; Terrorist Attack.

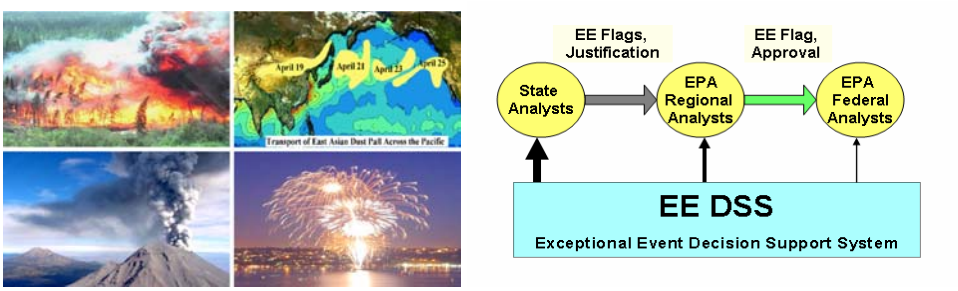

Fig. 1.(a.) Illustrative examples of exceptional sources. (b.) The main actors in the implementation of the Exceptional Event Rule and the users of EE DSS.

The decisions related to the Exceptional Event flagging are performed at three organizations: States, Regional EPA Offices and Federal EPA (Fig. 1b). The States need to decide whether a particular sample is to be flagged and prepare a flag justification report. The EPA Regional Offices evaluate the submitted flag requests. The Federal EPA ensures regional consistency of the flag justification evaluations, resolves difficult cases and provides general help interpreting the EE Rule.

The implementation of the EE Rule is ad hoc and unstructured. The guidelines for preparing the flag justifications are intentionally somewhat vague. Therefore, preparing and evaluating the evidence for flagged data is technically challenging both for the State and the Regulatory offices. It requires: Accessing a diverse data sources for various aspects of the exceptional event; Integration of the heterogeneous data sources that are frequently incomplete and incompatible; Performing detailed data analysis to establish "clear causal relationship" between the EE and the

exceedance. The Rule also requires a demonstration that the exceedance would not have occurred but for the presence of the EE. Lastly, the flagging procedure has to be in accordance with section 40 CFR 50.14 (c)(3)(iii) of the EE rule.

Currently, States are scanning their monitoring data for anomalous patterns and use media reports of fires, dust storms and other EEs. The impact of exceptional sources on the violating monitor site is justified in a qualitative manner. Many State and Regional EPA offices lack the means for executing these challenging tasks. As a consequence, the current justifications are highly variable; some States submit very detailed and technical reports while others are brief and descriptive. Also, the EPA Regional Offices currently use ad hoc qualitative methods to understand the events, to evaluate the claims, and to make their recommendation. The lack of formal procedures and tools makes evaluation difficult and uneven.

In his supporting letter, R. Neeley, Chief of the Air Toxics and Monitoring Branch, U.S. EPA Region 4 states: "*A standardized set of tools can also be useful for state and local agencies as they prepare exceptional events data analyses and documentation. Such standardized Web-based tools would save time and resources, as well as provide a consistent basis for EPA's decisions on the exclusion of exceptional events data from National Ambient Air Quality Standards calculations.*" Fortunately, there are now outstanding opportunities to develop credible and reasonably simple computer-supported methods for the preparation of flagging documentation through an EE DSS.

As the EE Rule has evolved, the Federal EPA has been supporting and interactively guiding our CAPITA group to explore the design and function of the EE DSS (Evidence, 2008). The preparation of this NASA ROSES proposal has also benefited greatly from the support, the ideas and the feedback from the Federal EPA. The proposed EE DSS will serve multiple end users: State Air Quality Offices as well as Regional and Federal EPA. The Federal EPA will continue to play a key role in the design and usage of the EE DSS because the Federal EPA develops the NAAQS and the associated Rules, which require considerable research on the nature of EEs and implementation options. The Federal EPA is also working to develop reporting templates for the EE DSS, which will aide the States' flag justification reports and ensure consistency among Regions. States will use the EE DSS to compile the evidence to support EE flags and prepare the flag justification reports. The Regional EPA offices will use the EE DSS to evaluate the flag justification reports.

The EE DSS will save time for both the States and the EPA. The preparation of the qualitative reports is currently time consuming. One rough estimate provided by an officer of the Federal EPA is that currently it takes about a week of State analyst's time to prepare an EE report. Currently there are hundreds of flagged data samples, for which justification requires several person-years of effort. As the implementation of the EE Rule proceeds and the States get more familiar with data exclusion procedures, it is anticipated that the number of flagged samples will increase by at least an order of magnitude to thousands of flagged samples per year. The proposed EE DSS is anticipated to reduce the report preparation time from about one week to less than four hours per flag. This factor of 10 time-savings can then be used more prudently on analyzing and understanding the State's air quality pattern or exploring mitigation options.

NASA Earth Science Research Results

The EE Rule does not have its own supporting data therefore it offers an outstanding opportunity to infuse NASA data products and information technologies deep into EPA's operational activities. The global-scale, high spatial resolution satellites remote sensing data are particularly suitable for detecting and quantifying natural and manmade air pollution events, dust, smoke, haze. The intense aerosol and gaseous pollutant signal during these events have made satellites indispensable in detecting and following the evolution of such events. Additional AQ benefits of satellites are on evaluating and improving emission inventories for NOx, biogenic VOC and particulates.

Unfortunately, until recently, the role of satellites in EPAs air quality regulatory process was very modest. In fact, the EE Rule is the only air quality regulation that we are aware of, where the use of satellites is explicitly encouraged, as seen in the quote snippets from the EE Rule in Federal Register (Treatment, 2007): Information demonstrating the occurrence of the event.. ... ***satellite****-derived pixels indicating the presence of fires;* ***satellite*** *images of the dispersing smoke; Identification of the spatial pattern of the affected area (the size, shape, and area of geographic coverage). This could include, for instance, the use of* ***satellite*** *or surface measurement data; The simplest demonstrations could consist of newspaper accounts or* ***satellite*** *images to demonstrate that an event occurred…*

The recent past and anticipated future use of satellite data is succinctly stated in his letter of support by N. Frank, the lead EPA scientist responsible for the development of the EE Rule: "... *the fusion of satellite-derived measurements from its multiple sensors, combined with ambient air pollution measurements, meteorological data, and modeled estimates have recently been shown to be very valuable to separate the complex sources of air pollution into anthropogenic and natural components and for understanding when events are allowed to be judged exceptional.*".

NASA-supported IT, particularly the Service Orientated Architecture and Service Orchestration is also directly applicable to the development and implementation of a DSS which is assembled from the distributed components of the project team. These technologies will markedly improve the quality of EE flagging process and also help the implementation of tools for EE Anomaly Detection, Surface-Satellite Data Fusion and Event Climatology Analysis.

The incorporation of NASA data products into the EE DSS is primarily through the rich capabilities and keen interest of the Co-I partners and collaborators of this project. The GIOVANNI data portal is a key access portal to the most widely used satellite products in AQ analysis, including MODIS and MISR AOT, OMI and more recently CALIPSO. GIOVANNI also provides an array of useful data processing and fusion services. In the NAAPS global aerosol model a number of NASA datasets are assimilated and used for validation. MODIS-derived fire location is derived hourly in real-time and converted into model-relevant emissions. The MODIS aerosol optical depth product is also operationally assimilated into NAAPS. The MODIS Dust Enhancement Product is used to identify dust sources globally for NAAPS. The AIRPACT modeling system actively pursues the verification of CMAQ model with OMI columnar data for urban-industrial as well as for major fire emissions.

Technical Approach

Description of EE DSS

The main purpose of this project is to support the implementation of EPA's new Exceptional Event Rule by developing and delivering a suitable Exceptional Event Decision Support System (EE DSS). The functionality of the system includes: (1) detection and description of EEs, (2) preparation of EE flag justification reports, and (3) evaluation and approval of the EE flags by Regional and Federal EPA. The corresponding activities supported by EE DSS include: accessing and processing data, analyzing events and preparing EE Justification reports. These tasks will be accomplished by three major components of EE DSS: (a) NEDS, Network for Event Decision Support, an infrastructure for accessing and integrating distributed EE-relevant data and models; (b) FASTNet, a networked community of analysts, for detecting, analyzing and describing exceptional events; (c) Tools and methods for preparing and evaluating EE Reporting.

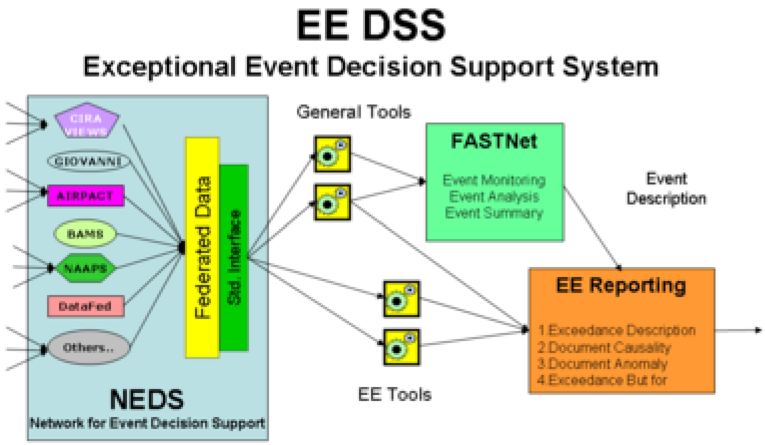

Fig 2. Architectural diagram of the Exceptional Event Decision Support System (EE DSS).

The three components of EE DSS working together constitute an end-to-end information processing system that takes observations as inputs and produces "actionable" knowledge necessary for EE decision making. This knowledge needs to be presented as evidence that an exceedance would not have occurred ***but for*** the impact of the exceptional event. Unlike traditional monolithic, closed "stove pipe" DSS, the proposed networked data system will follow a Service Oriented Architecture (SOA). In fact, the EE DSS will be a "network of networks". In NEDS, the data will be distributed through a *network of providers*. Similarly, in FASTNET, the collaborating analysts will form a *network of analysts*. It is also anticipated that with time the EE regulatory process will also include a *network of States, Regional and Federal EPA offices*.

Major components of the proposed EE DSS project have been developed in various projects over the past decade. At Washington University these projects included: DataFed supported by NSF, EPA, NASA and FASTNet (RPOs) (R. Husar, 2005), SHAIRED (SHAiRED, 2005) as well as work conducted by CAPITA while supporting EPA in preparation of the EE Rule itself. Similar developments at Co-I and Collaborating partners have also produced an impressive stock data, tools and methods relevant to EE DSS. These are to be linked and harmonized in this project. The new components of the proposed system are the EE-specific tools in the Exceptional Event Reporting Facility.

Given the years of experience in developing and using these components, the main challenge of this ambitious project will be "connecting the pieces" and enabling the networks of autonomous

nodes to produce societal benefits in the form of better air quality management. In this sense, the proposed DSS is a contribution toward the implementation of the Global Earth Observing System of Systems (GEOSS, 2006). In fact, Exceptional Event is an air quality scenario in the 2008 GEOSS Architecture Implementation Pilot (AIP) (Percivall, 2008; GEOSS, 2008). It will facilitate integrating and utilizing multi-sensory monitoring networks and enhance the connections among the key U.S. agencies NASA (science and technology), NOAA (operation), EPA (regulation). Equally important will be the connections and knowledge-sharing between the people: data providers, air quality analysts and regulators participating in the GEOSS AIP.

Network for Event Decision Support (NEDS)

The data required for Exceptional Event Analysis will be linked and federated using NEDS. The key roles of the federation infrastructure are to (1) facilitate registration of the distributed data in a user-accessible catalog; (2) ensure data interoperability using international, standard protocols; (3) provide a set of basic tools for data exploration and analysis.

Data Federation Architecture

Data federation is accomplished by turning data stored and exposed through a server into a data service. "Data as a service" makes it accessible to other computers through standard interfaces and communication protocols. Data providers *publish* data in a catalog, users *find* data in the catalog and when ready, they connect or *bind* to the selected data access service. In NEDS, federating data resources can and will be pursued as a gradual, non-disruptive process where providers expose their self-determined fraction of data resources as a web service. Users of the federated data can then access the federated resource pool through suitable catalogs as shown in Fig. 3a.

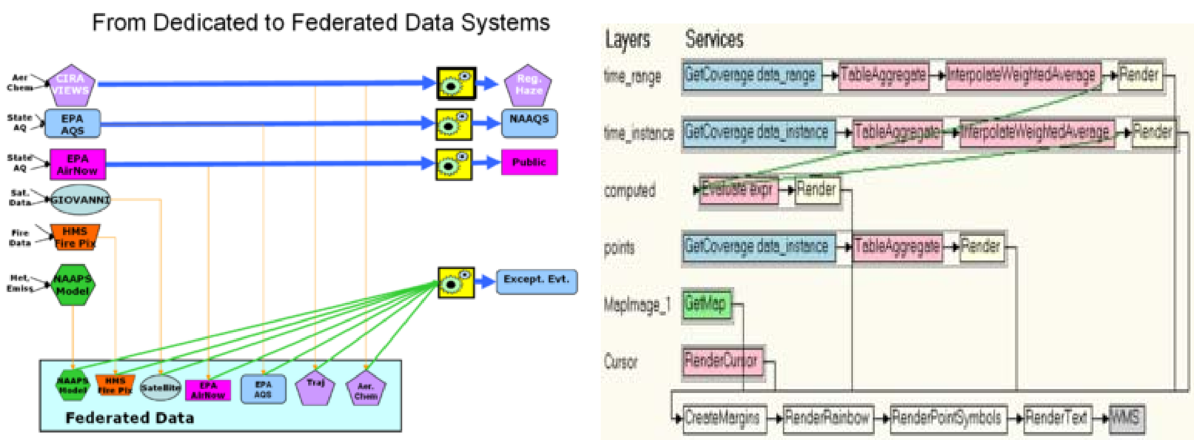

Fig.3 (a.) Federation of distributed data through standard data access services. (b). Typical service flow diagram. The services are organized as a stack of workflow chains, each row representing a data layer in a view.

From the user's perspective, federating the data makes the physical location irrelevant. This loosely-coupled networked architecture is consistent with the "publish-find-bind" triad of Service Oriented Architecture and also supports the GEOSS motto: "Any Single Problem Requires Many Data Sets. Any Single Data Set Serves Many Applications."(Zhao, 2006). In the case of NEDS,

for example, **all** the data needed for the EE DSS are accessed from the federated data pool. The EE Rule Implementation program does not have any data of its own. The Service Oriented Architecture (SOA) of DataFed and PULSENet is used to build web-applications by connecting the web service components (e.g. services for data access, transformation, fusion, rendering, etc.) in Lego-like assembly as illustrated in Fig. 3b.

Establishing the software connections for NEDS will be accomplished using standard interfaces including OGC WMS for image data and WCS for point and grid datasets. This universal access method is performed by ‘wrapping’ the heterogeneous data, a process that turns data access into a standardized web service so that data can be queried by spatial and temporal attributes and processed into higher-grade data products. User-contributed metadata and the communication between data providers and users will be facilitated through DataSpaces (E.Robinson, 2008), i.e. hybrid (structured/unstructured) wiki pages that are dedicated to metadata for each dataset.

The further development of the NEDS infrastructure is beyond the scope of this project since that development can be leveraged from other on-going projects such as the NASA REASON grant, SHAiRED, at Washington U.. However, special effort will be devoted to the core NEDS data sharing network, which is a subset of the available, pooled AQ data resources. It contains data serving nodes that are of particular relevance to exceptional event analysis. In the NEDS subset, the data flow will be harmonized by eliminating connectivity glitches and well-tested for persistency and robustness. NEDS will be the infrastructure for creating distributed, compound applications that are built by the combined effort of multiple organizations. Examples of these compound applications include the Combined Aerosol Trajectory Tool (R. Husar, 2004) and MODIS-Airnow tool at GIOVANNI (GIOVANNI, 2004). Details on the architecture can be found in a recent paper: DataFed: An Architecture for GEOSS (R. Husar, 2009).

Collaborating Participants in NEDS

The EE DSS project will achieve its goals primarily by linking, harmonizing, integrating and otherwise ‘connecting the pieces’ contributed by its autonomous core constituent partners represented by the projects GIOVANNI, NAAPS, VIEWS, AIRPACT, BAMS and DataFed. The nodes of NEDS working together constitute an end-to-end information processing system that takes observations as inputs and produces "actionable" knowledge necessary for EE decision making. Loosely coupled connections between data providers and data analysts along with an open, inclusive approach will promote the creation of an agile, responsive DSS that is capable of responding to the challenging and varied requirements of the Exceptional Event regulatory process. In order to satisfy the operational requirements of the end-user organizations (States, Regional and Federal EPA), the open, loosely-coupled networks will be fortified by a **core data network** and a core analyst network that can deliver required data, tools and analysis products to the EE DSS customers. The core networks will be composed of the co-investigators and collaborators of this project, who have declared their commitment to share their data resources.

Co-Investigators

VIEWS (S. McClure): The Visibility Information Exchange Web System (VIEWS, 2002) is an online decision support system developed to help federal land managers (FLMs) and states

evaluate air quality and improve visibility in federally-protected ecosystems according to the stringent requirements of the EPA's Regional Haze Rule and the National Ambient Air Quality Standards. The Technical Support System (TSS) is an extended suite of analysis and planning tools designed to help planners develop long term emissions control strategies for achieving natural visibility conditions in Class I Areas by 2064. VIEWS/TSS integrates numerous air quality and emission datasets into a single, highly-optimized data warehouse which enables users to explore, merge, and analyze diverse datasets. For this EE DSS project, the VIEWS/TSS program will make available the Air Quality data, participate in event analyses and make some of the DSS services/tools accessible.

NAAPS (D. Westphal): The Navy Aerosol Analysis and Prediction System (NAAPS, 1999) is a global operational aerosol, air quality and visibility forecast model that generates six-day, forecasts of sulfate, dust and smoke and the resulting visibility conditions worldwide. NAAPS is particularly useful for forecasts of dust events downwind of the large deserts and the transport of large-scale smoke plumes originating from boreal and tropical forests and the savannah. NAAPS includes innovative data assimilation from MODIS, Deep Blue, AERONET, and CALIPSO data. NAAPS' strength is in forecasting and simulating the timing of events. Simulations of contribution from outside the US will provide boundary conditions for regional AQ models such as AIRPACT-3 or CMAQ. Access to the NAAPS model outputs and other contributions are being covered in a companion NASA ROSES proposal, NASA and NAAPS products for AQ decision-making, by D. Westphal

GIOVANNI (G. Leptoukh): The GES-DISC (Goddard Earth Sciences Data and Information Services Center) Interactive Online Visualization ANd aNalysis Infrastructure (GIOVANNI, 2004) is a Web-based application that provides standards-based web access (WMS, WCS, OpENDAP) to NASA Earth science remote sensing data including MODIS, MISR, TOMS, MLS, CALIOP and GOCART. GIOVANNI will enable air quality scientists to identify regional air pollution sources and sinks. It will also help in tracking the intercontinental transport of atmospheric trace gases and aerosols from industrial pollution plumes, smoke or dust. GIOVANNI is also developing tools to provide vertically-resolved visualization of aerosol pollution by combining MODIS AOD and CALIPSO vertical distribution data. The vertical distribution of aerosols will enable air quality scientists to understand the vertical transport of aerosols.

AIRPACT (J. Vaughan): The AIRPACT-3 (AIRPACT-3, 2004) daily air-quality forecasting system offers an excellent resource EE DSS for Exceptional Events, such as smoke from wildfires or dust storms. To support the development of the proposed EE DSS, Vaughan will make AIRPACT-3 results available for evaluation of air-quality events of interest as potential exceptional events. Also, Vaughan will participate in analysis of candidate events by operating the AIRPACT-3 modeling system with alternative emissions scenarios or boundary conditions and participate in evaluation of the contribution of specific sources of interest. For example, in the case of candidate EE involving wildfires in the northwest, AIRPACT-3 can provide air-quality simulation results for scenarios both including and excluding regional forest fires, for which emissions are already automatically included in AIRPACT-3 simulations.

BAMS (J. McHenry): Baron Advanced Meteorological Systems' (BAMS, 1994) is developing a mission-critical commercial, national-scale air quality forecast decision support system (AQF-DSS). Operational forecasts are produced using MM5/SMOKE/MAQSIP-RT and CMAQ models which includes simultaneous assimilation of real-time satellite and surface aerosol observations. The new deep blue MODIS retrievals will improve initial and boundary conditions over CONUS, while the land-surface modeling system will better characterize the surface relative humidity critical to hygroscopic aerosol effects. The model simulations will help distinguishing exceptional events from pollution events. BAMS will make model results available for the evaluation of possible exceptional events, and will develop a boundary-condition interface to the NAAPS to better capture the effect of long-range transport from outside the regional-to-local domain where the event occurred.

DataFed (R. Husar): DataFed (DataFed, 2001) is a distributed web-services-based computing environment for accessing, processing and rendering environmental data in support of air quality management and science. The flexible, adaptive environment facilitates the creation of user-driven data processing value chains. DataFed non-intrusively wraps datasets for access by standards-based web services. Its federated data pool consists of over 100 datasets and the tools have been applied in several air pollution projects. DataFed contributes air quality data (as services) to the shared data pool through the GEOSS Common Infrastructure. It also hosts most of the EE DSS services and tools.

Collaborators

PULSENet (S. Falke): PULSENet (PULSENet, 2008) is a standards-based sensor web framework for access, display, processing, and dissemination of sensor data and tasking control of sensors. PULSENet is part of a NASA ESTO project titled, Sensor-Analysis-Model Interoperability Technology Suite (SAMITS), that is developing a package of standards, technologies, methods, use cases, and guidance for implementing networked interaction between sensor webs and forecast models. PULSENet will augment the EE DSS by providing standards-based interfaces to services suitable for workflow chaining in advanced application testing that ties together atmospheric, air quality, and fire sensors with smoke forecasting models.

Hazard Mapping System (T. Haberman): The NOAA/NESDIS Hazard Mapping System (HMS, 2003) integrates fire observations from multiple satellite sensors, human observations, and other sources. The HMS dataset is particularly useful for determining the spatial extent of smoke plumes identified by human interpretation of satellite images and extents of major fires. These data are provided as a web service by NOAA's National Geophysical Data Center.

BlueSky (S. Larkin): BlueSky (BlueSky, 2003) is a fire and smoke prediction tool used by land managers to facilitate wildfire containment and prescribed burning programs while minimizing impacts to human health and scenic vistas. BlueSky links computer models of fuel consumption and emissions, fire, weather, and smoke dispersion into a system for predicting the cumulative impacts of smoke from prescribed fires, wildfires, and agricultural fires. For the EE DSS, BlueSky may provide fire location and smoke forecasts that are prepared routinely as part of the interagency fire management program.

National Park Service (B. Schichtel): The National Park Service (NPS) has conducted air quality monitoring for the past 25 years for the purpose of protecting visual air quality near national parks. NPS is also performing extensive source and receptor analyses to establish the contribution of different sources. For the EE DSS the NPS contributions would include access to the IMPROVE data, air mass back trajectories for each of the monitoring sites, plume simulations of the smoke dispersion as well as other analysis tools and products. The data gathered through the EE DSS may also be beneficial for the air quality assessments and decision-making processes conducted in NPS.

End Users

The most important stakeholders participating in this project are the end users. Their roles are summarized below. More detailed explanation of their respective interests can be found in their letters of support.

Federal EPA (N. Frank): EPA is the driver for the introduction of the Exceptional Event Rule and also the evaluator of its implementation. The development of the EE DSS and its wide use by the States and Regional EPA offices throughout the development of the EE DSS, EPA will provide both guidance and evaluation. The Federal EPA ensures consistency between the Regional EPA evaluations.

State/RPOs (N. Poirot): The States perform the flagging of EE-influenced samples and also prepare the EE flag justification reports. Hence, the States are the most important users of EE DSS. Their inputs into the design, implementation and testing of the EE DSS will be crucial. In order to address more complex and/or regional issues, a group of States may cluster and form Regional Organizations such as the Regional Planning Organizations (RPOs) for Regional Haze.

EPA Region IV (D. Neely): The monitoring data samples that are flagged as exceptional will be evaluated by Regional EPA based on the EE Flag Justification reports submitted by the States. The flag evaluation will also incorporate the use of the EE DSS.

GEOSS (G. Percivall): The data sharing infrastructure of GEOSS is a mechanism that will allow the publication, finding and reusing the Earth Observation resources at an international scale. The role of GEOSS for this project is to provide an architectural framework through the GEOSS Common Infrastructure. As stated in his supporting letter *"Your proposed AQ Network would interoperate with services provided by other GEO Members and Participating Organizations in support of a the GEOSS Societal Benefit Area for Health. Your plans for data flows harmonized by eliminating connectivity glitches and well-tested for persistency and robustness supports the GEOSS network and would be the basis for creating distributed, compound applications that are built by the combined effort of multiple organizations."*

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FASTNET: Community Event Analysis Network

Full understanding and characterization of air pollution events is a very labor-intensive, subjective and sporadic process. Collecting and harmonizing the variety of data sources,

describing events in a coherent, compatible manner and assuring that significant events will not 'fall through the cracks' is a challenging task for research groups, but even more for State and Regional air quality analysts. The detection and characterization of short-term events is performed by monitoring a wide range of observations arising from real-time surface and satellite sensors, air quality simulations and forecast models.

The gathering of the distributed data and the tools for data exploration and processing are described through the constituent nodes of NEDS. Initial event analysis can be performed in real-time while, by necessity, the detailed event characterization that includes slower data streams is conducted post-facto. Conceivably, the event analysis performed in the community workspace could serve as triggers and guides to the States in deciding which station-data to flag. Real-time continuous PM monitoring provides the record for short term event detection. Time-integrated and less frequent speciated PM samples provide the chemical signatures for specific aerosol types, such as smoke or dust. Satellite images delineate both the synoptic-scale as well as fine-scale features of PM events under cloud-free conditions. The full integration of these diverse PM data arising from a variety of measurements is still a major challenge for the data analyst. Air quality models that assimilate the various observations could serve as effective data integration platforms. Unfortunately, the science and technology of such data assimilation is in its infancy.

We are proposing that general event analysis to be conducted by a virtual community of analysts. The FASTNET (Fast Aerosol Sensing and Tools for Natural Event Tracking) concept was introduced by Poirot, et al (R. Poirot, 2005). It began as an air pollution event detection and characterization project, which includes a set of tools, methods as well as a community of analysts. FASTNET was initially developed and supported by the Regional Planning Organizations (RPOs) for the characterization of major natural events relevant to the Regional Haze Rule. Forest fire smoke and windblown dust are particularly interesting events, due to their large emission rates over short periods of time, continental and global-scale impacts, and unpredictable sporadic occurrence. Such dust and smoke events are also the dominant causes of Exceptional Events under the EE Rule.

The FASTNET concept will be adopted to the specific needs of the EE Rule. The FASTNET for EE DSS will consist of a core group of analysts whose effort will ensure that: (a) Major EEs with exceptional impacts on many sites will be analyzed and described so that individual States can use well-documented, authoritative event descriptions. (b) The core group will be available for consultations or to perform special analyses for difficult EE cases identified by the State, Regional or Federal offices. (c) The core group will also guide the development of additional tools and methods for the general characterization of EEs by identifying new data sources, combining and fusing multi-sensory data and interacting with the event modelers and forecasters.

Community interaction for event characterization is particularly vital since aerosol events are being identified, recorded and to various degree analyzed by diverse groups for many different purposes. We propose to "harvest" the event analyzes being conducted by groups and to combine it with analysis being done by FASTNET community serving NEDS. In the past the virtual community of analysts have been connected by ad-hoc means. It is hoped that through this project, the virtual workgroups may receive more extensive and powerful tools and technical support in form of Analyst Consoles, Anomaly detection tools, collaboration space and more

effective communication. This collaboration support will allow better harvesting of the experience and insights of the broader interested community.

The FASTENET virtual community of analyst will conduct much of its business on open wiki workspaces (Robinson, 2008) where each event will be assigned an EventSpace with information on data, interpretation, discussion and community-produced event summary. Two classical event workspaces are for the 1998 Asian Dust Event (R.Husar, 2001; Asia, 1998) and 1998 Central American Smoke (Central, 1998). EventSpaces for more recent events include Georgia Smoke (070420GeorgiaSmoke, 2007) and Southern California Fires (071022SCalSmoke, 2007). A searchable Event Catalog will facilitate the finding and reuse of past event analyzes. The organization, statistics and spatial-temporal display of past aerosol events by type is also helpful in developing a long-term climatology of events. The 10-year NAAPS Model dataset will also be an important resource for event climatology analysis (to be provided by a companion ROSES project).

The output of the community event analysis includes event characterizations as contributed by the joint effort of the participating community. These event descriptions are integrative and general purpose so that they are applicable to many users, such as informing the public, improving the model forecasts as well as advancing atmospheric science. The community-based event descriptions provide broader context extending well beyond the territory of any state.

EE Reporting Facility

The EE Reporting Facility is devoted to satisfy the specific needs of the EE Rule implementation. It constitutes the main development activity of the proposed project. The facility will be used by the States to prepare the flag justification reports which are then submitted to Regional EPA. The facility will also be used by the Regional and Federal EPA to evaluate the submitted flag justifications. In the initial application, the EE Reporting Facility would be used to prepare the reports months after the event has occurred. However, in the future this reporting facility could perform some of its functions in near-real-time. The EE Reporting Facility includes a comprehensive set of tools and methods for preparing and evaluating EE justification reports. The Flag Justifications have to provide EE evidence in accordance with the four sections, A-D, expressly stated in the Exceptional Event Rule.

Section A: Exceedance Description

The purpose of this section A is to demonstrate that the event satisfies the criteria set forth in 40 CFR 50.1(j), i.e. that there is a potential pollutant source which is not controllable or preventable, such as forest fires, dust storms, or pollution from other, extra-jurisdictional regions. It is also necessary to establish whether a site is in potential violation of the PM2.5 daily (35ug/m3) or annual (15ug/m3) standard. The evidence needed for this component is gathered from multiple sources, each responding to different requirements, including the event description, the presumed uncontrollable source, potential violation of NAAQS.

Preparing the section A of EE flag justification will draw upon NOAA's Hazard Mapping System, HMS (T. Habermann) for the fire locations, BlueSky (S. Larkin) for general fire

description, and on public news sources. The general event description will be performed by the FASTNet community.

Section B: Clear Causal Relationship between the Data and the Event

The main scientific-technical challenge arises from the requirements of this clause B: Establishing a clear causal relationship between the flagged sample and the event that is claimed to have affected the air quality in the area. For PM pollution, for example, the complications arise from the fact that many different source types contribute to PM2.5 concentrations. Some anthropogenic, others are natural; some are located nearby, others can be far away. Emissions from natural and 'extra-jurisdictional' sources, such as biomass fires and windblown dust or intercontinental pollution transport can be significant contributor to PM events. However, quantification of the contributions of these extra jurisdictional events is still.

The evidence for this section includes (1) backtrajectory analysis to establish whether the air masses associated with the exceedance pass through the source region of the exceptional source. (2) Speciated aerosol data showing unusual chemical composition, e.g. organics for smoke, soil components for wind-blown dust, and potassium for July 4th. (3) Forward model simulations can also indicate a causal relationship. (4) Temporal signatures (spikes) may also yield additional evidence.

While none of the evidence provides proof, the combination of evidence from multiple independent perspectives can provide sufficient weight for decision making. Hence, the purpose of this report section and these tools is to illustrate the multiple lines of evidence and how to combine these for making a strong argument. The selection of datasets and tools as well as the presentation of the evidence is in the hands of the analysts.

A compelling line of evidence for exceptional events arises from satellite observations. Near real-time satellite images and data products are useful for the identification of exceptional events such as forest and agricultural fires, wind-blown dust events. The fire pixels, obtained from satellite and other observations, provide the most direct evidence for the existence and location of major fires. The AOT shows the spatial extend of EE pollutants. The Absorbing Aerosol Index (AI) provided by the OMI satellite sensor reveals the smoke/dust in the immediate vicinity of the source. The lack of AI signal further away from the source indicates one of the possibilities: absence of aerosol, the aerosol is below a cloud and therefore not visible from the satellite. Also, the OMI smoke signal is most sensitive to elevated smoke layers, while near-surface smoke is barely detected by the Absorbing Aerosol Index.

One line of evidence for causal relationship is by combining the observed source of an exceptional event with backtrajectories of high concentration events. In Fig. 4. below, we show the color coded concentration samples along with the backtrajectories which show the air mass transport pathway (R. Husar, 2004).

Model simulations and forecasts may also provide evidence for exceptional events. For example, the ability of regional and global-scale models for forecasting wind-blown dust events is continuously improving. This is evidenced by the good performance of the Naval Research

Laboratory NAAPS global dust model. The simulation and forecasting of major smoke events is much more difficult due to the unpredictable geographic-time-height-dependence of the biomass smoke emissions. Hence, currently reliable and tested smoke forecast models do not exist, however, models such as BAMS' CMAQ which will be ingesting Deep Blue and surface data, with boundary conditions to-be-linked w/ NAAPS, show promise. Same holds for the AIRPACT CMAQ model.

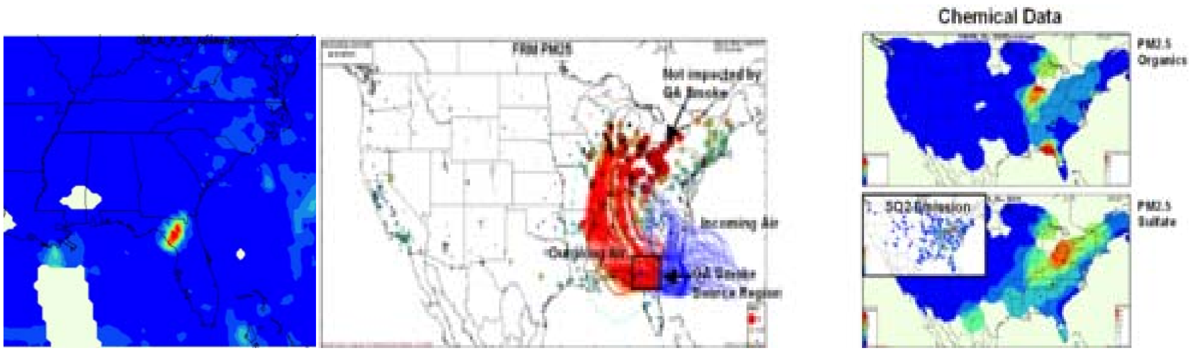

Fig. 4. (a.) MODIS AOT of Georgia Smoke. (b.) CATT smoke transport simulation (c.) Aerosol organics and sulfate pattern based on VIEWS data.

Establishing causality between alleged sources and site exceedances is a scientifically challenging task since it requires the establishment of a quantitative and defendable source-receptor relationship. Establishing such relationship for EEs exacerbated by the unpredictable emission location and time and usually complex transport processes. The organizational challenges stem primarily from the need to acquire observations from many organizations. The key implementation challenge is the proper integration of the multiple lines of evidence for estimating the causality of the anomalous source impact.

This important report section will utilize virtually the entire network of collaborating investigators. Satellite data from GIOVANNI (G. Leptoukh) and other portals will be used to characterize the spatial pattern. The integrated multi-satellite data from the A-Train constellation will provide a richly textured pollutant pattern, including vertical distribution from CALIPSO. The array of chemical transport models will provide estimates of source-receptor relationships. The NAAPS model (D. Westphal) will cover the global scale emissions and transport and offers boundary conditions for regional scale models including AIRPACT, (J. Vaughn), BAMS (J. McHenry). The chemical fingerprints for receptor-oriented source attribution will be provided by the VIEWS data base (S. McClure). Individual plume simulations for smoke and other events will be contributed by the National Park Service (B. Schichtel).

Section C: The Event is in Excess of the "Normal" Values

The purpose of this section is to demonstrate that the event is associated with a measured concentration in excess of normal historical fluctuations, including background. Establishing the magnitude of normal, historical values can be performed through any number of statistical measures since air pollution varies in space, time and also depends on the pollutants. The sulfate pattern, for example, is very different from nitrate, organics or dust. Thus, the metrics that

meaningfully describe the "normal" historical pattern require many parameters including space, time composition along with those from parametric and/or nonparametric statistics. A useful measure of the "normal" concentration is the high, say 95th percentile, for a given station. A sample is considered anomalously high (deviates from the normal) if its value are substantially higher than the 95th percentile for a given location and season.

In the figures below, the concentration and anomaly patterns are illustrated. Fig. 5a shows the time series of the daily average concentration, the 95th percentile concentration and the excess above the 95th percentile values. This figure illustrates a possible method for automatically detecting EE anomalies based on historical data.

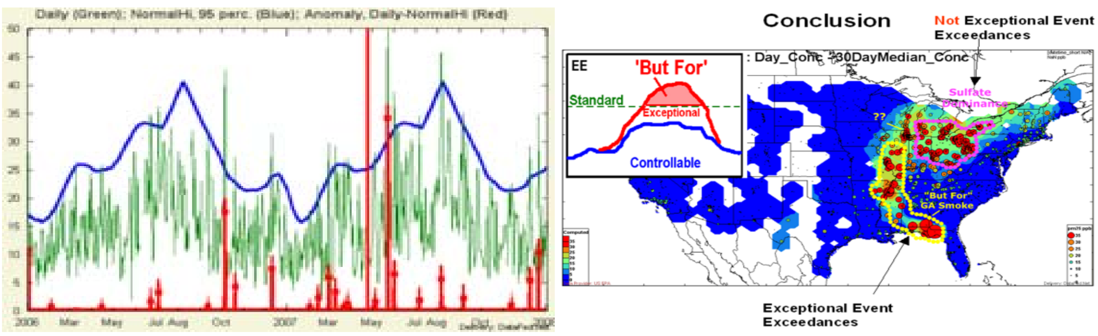

Figure 5 (a.) Time series of FRM PM2.5, 95 Percentile and Anomaly signals (b.) Spatial pattern for 'but for' impact of Georgia smoke and 'normal' pollution episodes.

The challenges for this section include: (1) what should be the specific metric for the "normal" high concentration (2) what should be the excess above normal high value to qualify for exceptional high. When suitable metrics for normal are derived we will develop tools that automatically calculate the anomalies and display those through appropriate visualization of spatial and temporal anomalies.

Establishing the normal pattern will draw upon the EPA PM2.5 regulatory monitoring network, the real-time AIRNow monitoring network, surface visibility data, and historical speciated data from VIEWS (S. McClure). The historical MODIS and TOMS data will be accessed through GIOVANNI. The event climatology of global-continental scale transport will be derived from the 10-year simulation performed and made available through the NAAPS program.

Section D: The Exceedance would not Occur, But For the Exceptional Event

The ultimate test whether a sample can be flagged is the "but for" condition, i.e. the exceedance would not have occurred "but for" the presence of the exceptional event. (See Fig. 5b.) "But for" is a very stringent condition to satisfy. The "but for" condition also places extreme demands on the analysts and the DSS for gathering the supportive evidence. In essence, it is required to perform a source apportionment of the measured ambient concentration that separates the "normal" and the exceptional source contributions. The "normal" includes the industrial and normal natural contributions from nearby sources that typically occur at a given location and season.

The design of the EE Reporting Facility is being pursued as part of a modest effort supported by EPA. The developing design and testing is documented on the open, Exceptional Event wiki workspace, (Evidence, 2008). This facility draws upon resources and tools of NEDS and FASTNET.

At this time practical, reliable and generally applicable tools for producing "but for" evidence are sparse. EE flags are being evaluated semi-qualitatively by consolidating and weighing a variety of corroborating evidence. A unique opportunity exist for quantitative 'but for' estimates using regional chemical simulation models. Both AIRPACT (J. Vaughn) and BARON (J. McHenry) modeling participants offered model runs for events, with and without the presumed EE source. In some cases the chemical fingerprints derived from the VIEWS (S. McClure) database can also establish the 'but for' condition.

Tools for EE Report Preparation

Standards-based data access permits the development of generic tools for data exploration, processing and visualization; some are yet to be fully developed for the Exceptional Event Rule implementation. All the tools leverage the benefits of OGC standards-based service oriented architecture: Each tool is applicable to multiple datasets; Service orchestration makes it easy to create new tools. While these tools are built on the DataFed infrastructure, efforts will be made to use the web-based tools of partners in the network.

In his supporting letter, R. Neeley, Chief of the Air Toxics and Monitoring Branch, U.S. EPA Region 4 states: *"Since the promulgation of the exceptional events rule (40 CFR 50.14), our regional office has reviewed a large amount of $PM_{2.5}$ ambient air monitoring data that our state and local agencies have flagged as influenced by exceptional events. This process has required significant amounts of time and effort. We have found the tools you have developed to be very useful for the review and analyses of exceptional events. "*

The **DataFed Browser/Editor** is the primary tool for the exploration of spatial-temporal pattern of pollutants. The multi-dimensional data are sliced and displayed in spatial views (maps) and in temporal views (timeseries). The browser is also an editor for data processing workflows using a dedicated SOAP-based workflow engine. A typical workflow for map view is shown in Fig. 3b. **Google Earth Data Browser**, is a dynamically linked software mashup between DataFed, and Google Earth that can browse the spatial views of any federated dataset. It is particularly suitable for the overlay and display of overlapping, multi-sensory data and temporal animations.

Analyst Console An Analysts Console (or dashboard) is a facility to display the state of the current aerosol system. It is anticipated that the Analysts Consoles will be the key dashboards for establishing the emergence, evolution and dispersal of exceptional events.

Concentration Anomaly Tool is to be developed and used operationally by the States and EPA to provide an automatic calculation of the normal pattern of air quality or as the deviation from the normal. It calculates concentration 'normals' and anomalies.

Combined Air Quality Trajectory Tool (CATT) combines the observed source of an exceptional event with backtrajectories of high concentration events. Color coded concentration

samples along with the backtrajectories which show the air mass transport pathway.

Transition Approach

The end-state of the EE DSS will be an operational system managed and maintained by the key stakeholders: Federal and Regional EPA and the States. The transition to the post-project operational phase will be a smooth and natural completion of our research group's participation in the EE Rule evolution. Since 1998, the PI and his co-workers have facilitated or participated in dozens of air pollution event analyzes, most notably the "Asian Dust Events of April 1998" (Asia, 1998; R. Husar, 2001), which documented exceptional impacts of Asian dust on Western North America. The analyzes of Central American Smoke of May 1998 (Central, 1998) caused record PM2.5 concentrations over much of Eastern U.S. and prompted EPA to issue the first set of guidelines on the treatment of EEs in compliance calculations. Recent EE analysis examples include the impact of Georgia Smoke on sites in the Eastern U.S. in May 2007(070420GeorgiaSmoke, 2007) and the Southern California Smoke event of October 2007(071022SoCalSmoke, 2007).

Upon EPA's request, the CAPITA group has actively participated in the development of EE analysis methods and contributed through exploratory illustrations of the candidate EE analysis methods (Evidence, 2008). These were included in the Federal Register Docket as supporting documentation for the EE Rule. After the formal publication of the EE Rule in the Federal Register (Treatment, 2007) the CAPITA group was again asked to provide further illustrations of the methods that satisfy the EE Rule (Evidence, 2008). The experience from both projects has clearly demonstrated that satisfying the regulatory requirements of the EE Rule can be supported by a suitable formal EE DDS information system. The need for such a support system has been strongly voiced by the supervising EPA officer and seconded by regional and State analysts who have seen and used those tools. (ref - Region 4 Georgia)

The transition of this AQ decision support project into a persistent operation is best expressed and illustrated in his letter of support by R. Poirot, CT Air Quality Planner, and also member of EPA’s Clean Air Science Advisory Board, Co-Chair of RPOs Monitoring and Analysis Committee etc.. “*It is especially gratifying to see that NEDS will build directly on the existing DataFed infrastructure and utilize several related applications including the VIEWS, FASTNET and CATT tools which were specifically requested by and developed for the multi-state Regional Planning Organizations (RPOs). These “user designed” RPO data acquisition and analysis tools continue to attract and support a dynamic, collaborative network of empowered data analysts. By adding better connections to various NASA data products like GIOVANNI (and associated NASA science expertise), and adding other perspectives such as quantitative estimates of intercontinental smoke, dust and sulfate impacts from the NAAPS global aerosol forecast model and regional impacts from the AIRPACT forecast model, the NEDS project will substantially enhance the power and use of these existing analysis tools and provide invaluable assistance to state and EPA Air managers for implementing the complex new EE Rule. I look foreword to collaboration on this project in the near future*."

Specific activities in the transition phase will include workshops and instruction sessions that will include the State, Regional and Federal AQ managers as users of the EE DSS system. The technical support will also include extensive web-based instructions provided through the EE DSS community workspace. As in the past, user workshops will be held on the use of DataFed,

FASTNet, CATT and other tools voluntarily contributed by the Co_I team and others. In this project, special effort will be placed on harnessing the contributions of the partners.

Performance Measures

The most direct measure of the EE DSS performance is the number of flagged samples and the time required for the preparation and evaluation of the flag requests. Additional measures include the amount of data accessed, explored and used in the reports. A more subtle performance measure is the ratio of the requested and approved EE flags.

The preparation of the qualitative reports currently takes about a week and there are hundreds of flagged data samples requiring several person-years of effort. As the implementation of the EE Rule proceeds and the States get more familiar with data exclusion procedures, it is anticipated that the number of flagged samples will increase by at least an order of magnitude to thousands of flagged samples per year. The proposed EE DSS is anticipated to reduce the report preparation ten-fold.

Data usage in the EE DSS is the next important measure of system performance. The usage determined both by the ‘user pull’ forces (e.g. data relevance, data quality), as well as by the provider push (e.g. ease of access, tools for processing). The federated data access system using a common service orchestration engine will allow the counting of data accesses in fine detail. This will provide valuable measures on the most used datasets, requested formats and the frequency of tools use segmented by user type and location. Currently we use Google Analytics to analyze the DataFed service usages by the visitors, traffic sources and target contents requested and for how long. A key desired metric will be the number and distribution of State analysts who use the DSS. The user group membership will also be assessed by the numbers of attendees to the planned workshops during the project.

Cost savings in data use metric can be approached using two methods. 1) For those end users who had not used remote sensing data prior to the information services due to prohibitive cost, we can quantify the difference in cost between the estimated prohibitive level and the costs associated with using the developed information services. 2) For those users who have been using NASA data on a consistent basis both before and after the system, we can quantify the cost savings by the difference between costs incurred by the end user both before and after the system was implemented. These same user groups can be surveyed to determine if there was a change in data quality or in the quality of their own products and decision support system. The groups can also be surveyed to determine new capability gains by end users and user satisfaction. Surveys will likely be conducted during the planned workshops.

Anticipated Results

This project is built on the hypothesis that a powerful EE DSS tool will make the implementation of the EE Rule better, faster, cheaper, and more consistent. The hypothesis has been partially validated though developments and testing over the past 3 years. The EE Rule is a new regulatory activity without a prior DSS. Thus, a "baseline" performance for the DSS only exists isolated tests and examples. However, the improvements to be added by the proposed EE DSS can be clearly stated and well quantified (a) EE DSS will provide a formal venue for adding NASA Earth observations into AQ regulatory processes. (b) The powerful EE tools will make the Exceptional Event documentation easy and efficient. (c) For EPA, the standardized DSS tools will make the decisions more consistent and robust. (d) The NEDS infrastructure will also have broader benefits for the implementation of SOA, e.g. GEOSS.

The anticipated results of this project from the perspective of a State Air Quality Analyst is well-stated in his letter of support by R. Poirot: *"The NEDS project will provide direct and much needed support to State and EPA Air Quality Management Agencies as they work to better understand and implement EPA's new Exceptional Event Rule… In addition to this DSS support, I believe there will also be multiple "ancillary benefits" that result from NEDS, since in the course of identifying and documenting the relatively few events which are ultimately designated "exceptional" by EPA's current rule, we - the networked teams of State, EPA, NASA and academic air quality analysts - will inevitably come to a better understanding of the nature and causes of many air pollution events of varying causes, spatial and temporal extents, and degrees of severity. This will aid the development of improved emission inventories, improve estimates of air quality model boundary conditions, lead to better model performance evaluation criteria for dispersion and receptor models, and provide valuable insights to air quality forecasters and health effects researchers."*

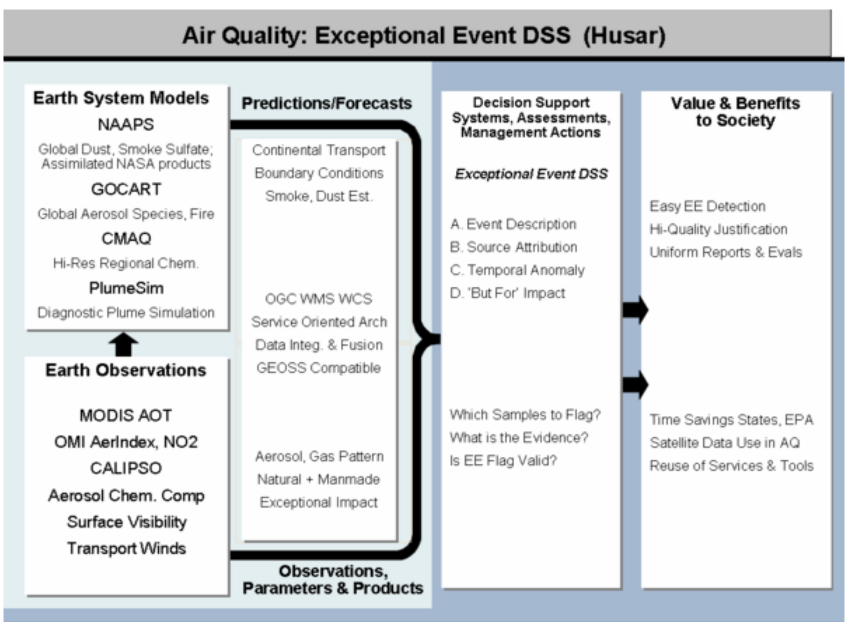

Fig 6. ISS diagram for for EE DSS.

The overall Integrated System Solution (ISS) diagram of the project is shown in Figure 6. The broader benefits of this are project will include deeper scientific understanding of EEs and innovative application of remote sensing and information technologies to AQ regulatory processes. Building the EE DSS will also contribute to the creation of a persistent core network for supporting AQ applications. The network will also exemplify multi-organization/agency collaboration using the principles and architecture of the Global Observing System of Systems

Project Management

The proposed project will be a prototype for a novel collaborative approach to project management based largely on the 'System of systems' principles of GEOSS. The autonomous groups (data systems) participating in this project are keenly interested in sharing their experience and resources and forming a functioning 'system of systems'.

Project CO-I and Collaborators: (this section is to be extended on Monday, Tue to incorporate the specific contributions of the co-i, collaborators; expand this paragraph to full page) The project will achieve its goals primarily by linking, harmonizing and integrating and otherwise ‘connecting the pieces’ contributed by its autonomous core constituent partners represented by the projects GIOVANNI, NAAPS, VIEWS, AIRPACT, BARON and DataFed. The responsibilities are also distributed. The NASA GIOVANNI Group will provide key satellite data to the core network under direction of Senior Scientist, Greg Leptoukh. The VIEWS data system (Shawn McClure) will provide key aerosol chemical data to the core network. Washington State U. (Joseph Vaughn) will provide AQ forecast model data for the Northwest and also participate in air pollution event analysis. Baron Adv. Met. Services (John McHenry) will provide regional scale air quality simulation and forecast. The Naval Research Lab. (Doug Westphal) will provide global-scale model forecasts as an indicator of continental-scale transport.

In our view, the CAPITA group is well suited as the coordinator for this NASA ROSES Application and Decision Support project. The unique characteristics of CAPITA are the parallel expertise in the domains of air pollution science as well as in the application of information technologies. Being a small group (6-8 people), CAPITA does not have the resources to fully engage in both activities simultaneously but rather in sequential cyclic waves. We expect that with the past emphasis on IT development, the next five years at CAPITA will be devoted to the application of the advanced IT tools air quality applications.

Coordination and Integration: The loosely coupled 'system-of-systems approach will be fortified with concrete goals.The project will have clear deliverables in the form of the functioning EE DSS. The responsibility for overall coordination and for the delivery of the functioning EE DSS will be that of the PI, R. Husar, director of CAPITA. His group will also deliver most of the EE-specific tools through their federated data system DataFed. Husar has over 35 years of experience in event analysis and associated data processing and analysis. He has been providing tech/science support to EPA both as researcher as well as in high level advisory capacity.

The software development for the DataFed tools will be performed by Kari Hoijarvi whose experience includes about 15 years of software development at CAPITA. The project coordination will be supported by Erin Robinson, PhD student in Engineering, whose research includes collaboration support through new web technologies.

Management Approach: The specifications and the design of the EE DSS will be overseen by an advisory group which will be lead by user representatives from EPA, and the States and also include data providers and mediators. The advisory group will meet on a teleconference held at

least every six months. A “virtual community” website will be created to allow team members as well as other interested parties to test and use the latest versions of data and tool services as well as submit comments. This interactive website will follow the well-established pattern of interactive web sites operated by CAPITA since mid-1990s.

Project will be open for the participation by the ESIP AQ and technical community. Also, ESIP will be one of the venues to link this project to other complementary projects. Project meetings are also planned to be in conjunction with the ESIP meetings. The upcoming participation in the GEOSS Architecture Implementation Pilot (AIP), AQ Scenario, will be a specific forum for open collaboration. Given the broad interest in EEs, the multitude of EE-related at local, regional, national and international level, it is anticipated that additional linkages will be established. For instance equivalent regulations to US Exceptional Event Rules are being considered by the European Environmental Protection Agency.

A summary of work activity by task and team members is given in the Table 1 below. The tasks are Data Provision (NEDS), EE analysis (FASTNET), EE Tools Development and data export from NEDS to other non-EE uses. The entries 1,2,3 indicate which project year the activity will be performed. Clearly, this is a rough work plan that will be adopted to the circumstances of the evolving collaboration process. The particular datasets federated in NEDS, the specific event analyzes and the full list of tools will be developed in year 1. However, it is firmly committed that the EE DSS will be functional by the middle of project year 2.

Schedule

The schedule of this three-year project will give explicit consideration to the fact:

- Substantial amount of preliminary work has already been prepared
- The proposing team has considerable resources and activities that has baring on the design and implementation of the project
- The EE DSS will proceed in parallel along all three components (Data Network, FASTNET and EE Tools), so that at any given time there is a functioning EE DSS that is being refined iteratively through user feedback.

In Year I, the detailed specification of the EE DSS will be completed driven primarily by the needs of the end users. Also, the core standards-based data connectivity network will be expanded from DataFed to include the other Data systems. The main EE Tools will be developed. Year I will include participation in the GEOSS Architecture Implementation Pilot.

In Year II, focus primarily on exposing the EE DSS to the State, Regional and Federal EPA. including a complete user-friendly interface, help instructions, tutorials and facilities for proactively gathering and incorporating user feedback.

In Year III will be devoted largely to the establishment of the operational EE DSS that will become the supporting decision system for the long-term implementation of the EE Rule.

Table 1. Project summary by team member and activity. The numbers indicate the year in which the activity is performed.

Team Member /Activity	Contact	Data Provision	Event Analysis	EE Tools	EE Reporting	NEDS Export
Investigators						
VIEWS	S. McClure	1,2,3	3	3		3
NAAPS	D. Westphal	1,2,3				
GIOVANNI	G. Leptoukh	1,2,3		2,3		1,2,3
AIRPACT	J. Vaughan	1,2,3	1,2,3	1,2,3		1,2,3
BAMS	J. McHenry	2,3				3
DataFed	R. Husar	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
Collaborators						
PULSENet	S. Falke			2,3		1,2,3
HMS	T. Habermann	1,2,3	1,2,3	1,2,3		2,3
BlueSkys	S. Larkin	2,3	2,3	2,3		2,3
NPS	B. Schichtel	1,2,3	2,3	2,3		2,3
End Users						
State, RPO	R. Poirot		1,2,3		2,3	
Region 4 EPA	R. Neeley		2,3		2,3	
Federal EPA	N. Frank		2,3		2,3	
GEOSS	G. Percivall	2,3				1,2,3

Statements of Commitment

Co-Is:

- G. Leptoukh
- S. McClure
- J. McHenry
- J. Vaughan

Collaborators:

- S. Falke
- R. Habermann
- S. Larkin
- B. Schichtel
- D. Westphal

Statement of Commitment – Individuals

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

Reply to Attn of: Code 610.2

30 Jul 2008

Professor Rudolf B. Husar
Washington University
1 Brookings Dr
Saint Louis, MO 63130-4862

Dear Dr. Husar,

I acknowledge that I am identified by name as a Co-Investigator to the investigation entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule," which will be submitted by you to the NASA Research Announcement NNH08ZDA001N-DECISIONS, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and my institution's budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

Cordially,

Dr. Gregory Leptoukh
Physical Scientist and Science Data Manager
Goddard Earth Sciences Data and Information Services Center
Code 610.2

Erin Robinson <erinmr@gmail.com>

Letter of Commitment, re: NASA ROSES 2008 NNH08ZDA001N

McClure, Shawn <McClure@cira.colostate.edu> **Thu, Aug 7, 2008 at 2:31 PM**
To: "rhusar@me.wustl.edu" <rhusar@me.wustl.edu>
Cc: Erin Robinson <emr1@wustl.edu>

Dear Dr. Husar:

I acknowledge that I am identified by name as Co-Investigator(s) to the investigation, entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule" that is submitted by Dr. Rudolf Husar to the NASA Research Announcement NNH08ZDA001N and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

Sincerely,

Shawn McClure

Senior Software Engineer, Research Associate III

Cooperative Institute for Research in the Atmosphere

970-491-8455

mcclure@cira.colostate.edu

BARON ADVANCED METEOROLOGICAL SYSTEMS

August 12, 2008

Rudolf B. Husar
Professor and Director
Center for Air Pollution Impact and Trend Analysis (CAPITA),
Washington University,
1 Brookings Drive, Box 1124
St. Louis, MO 63130
314 935 6099

Re: Proposal titled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule."

Dear Professor Husar,

I acknowledge that I am identified by name as Co-Investigator to the investigation, entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule." that is submitted by Dr. Rudolf Husar to the NASA Research Announcement NNH08ZDA001N and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

Best regards,

John N. McHenry
Chief Scientist
Baron Advanced Meteorological Systems
Phone: (919) 424-4443
E-mail: john.mchenry@baronams.com

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Joseph K. Vaughan, Ph.D.
Research Assistant Professor
Laboratory for Atmospheric Research
Department of Civil and Environmental Engineering
Washington State University
Pullman, WA, 99163

August 1, 2008

Rudolf Husar
Center for Air Pollution Impact and Trend Analysis
Washington University
Campus Box 1124
St. Louis, MO 63130-4899

Dear Professor Husar:

I acknowledge that I am identified by name as Co-Investigator to the investigation entitled '**Air Quality Management Applications of Earth Science Observations and Models: Exceptional Events**', that is being submitted by you, Rudolf Husar, in response to the NASA Research Announcement: *ROSES 2008: A.18 Decision Support through Earth Science Research (NNH08ZDA001N-DECISIONS)* and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

I look forward to working with you and others on this project.

Sincerely,

Joseph K. Vaughan

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Rudolf B. Husar
Professor and Director
Center for Air Pollution Impact and Trend Analysis (CAPITA),
Washington University,
1 Brookings Drive, Box 1124
St. Louis, MO 63130
314 935 6099

Re: Proposal titled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule."

Dear Rudy:

I acknowledge that I am identified by name as Collaborator to the investigation, entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule" that is submitted by Dr. Rudolf Husar to the NASA Research Announcement NNH08ZDA001N and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

We are excited by the prospects of collaborating with the rest of your project team to incorporate sensor web technology and architecture into the Networks for Exceptional Event Decision Support (NEDS). Our present work, as part of a NASA AIST funded project, in developing standard interfaces between sensors and smoke forecast models can provide supporting information for exceptional event decision support as well as standards-based interfaces for acquiring new sensor observations driven by NEDS user requirements.

I am pleased to be a founding member of this seminal alliance and I look forward to participating as a collaborator to help achieve its ambitious and important goals.

Sincerely,

Stefan Falke

Stefan Falke, D.Sc.
Geospatial Information Services for Energy & Environment
Northrop Grumman Information Technology

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE
Office of the Director
NATIONAL GEOPHYSICAL DATA CENTER
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August 12, 2008

Rudolf B. Husar
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Washington University,
1 Brookings Drive, Box 1124
St. Louis, MO 63130
314 935 6099

Re: Proposal titled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule."

Dear Dr. Husar:

I acknowledge that I am identified by name as Collaborator to the investigation, entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule." that is submitted by Dr. Rudolf Husar to the NASA Research Announcement NNH08ZDA001N and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

Sincerely,

Ray E. Habermann
Enterprise Data Systems Group Leader

TELEPHONE (303) 497-6215
FAX (303) 497-6513 VOICE/TDD (303) 497-6958
INTERNET */ngdc.info@noaa.gov/*

United States Department of Agriculture **Forest Service** **Pacific Northwest Research Station**

Pacific Wildland Fire Sciences Lab
400 N. 34th Street, Suite 201
Seattle, WA 98103
Phone (206) 732-7849
Fax (206) 732-7801

Date: August 13, 2008

Rudolf B. Husar
Professor and Director
Center for Air Pollution Impact and Trend Analysis
Washington University
1 Brookings Drive, Box 1124
St. Louis, MO 63130

Re: Proposal titled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule."

Dear Dr. Husar:

I acknowledge that I am identified by name as Collaborator to the investigation, entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule." that is submitted by Dr. Rudolf Husar to the NASA Research Announcement NNH08ZDA001N and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation. The U.S. Forest Service AirFire Team and BlueSky Science Team look forward to working with you on this important project.

Sincerely,

/s/ Narasimhan Larkin

Dr. Narasimhan K. ('Sim') Larkin
BlueSky Smoke Modeling Framework Project Lead
Research Physical Climatologist
AirFire Team, Managing Disturbance Regimes Program
U.S. Forest Service Pacific Northwest Research Station

United States Department of the Interior

NATIONAL PARK SERVICE
Air Resources Division
P.O. Box 25287
Denver, Colorado 80225

August 11, 2008

Rudolf B. Husar
Professor and Director
Center for Air Pollution Impact and Trend Analysis (CAPITA),
Washington University,
1 Brookings Drive, Box 1124
St. Louis, MO 63130
314 935 6099

Re: Proposal titled “Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule.”

Dear Dr. Husar:

I acknowledge that I am identified by name as Collaborator to the investigation, entitled “Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule.” that is submitted by Dr. Rudolf Husar to the NASA Research Announcement NNH08ZDA001N and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

Sincerely,

Bret A. Schichtel, Sc.D.
Physical Scientist

Erin Robinson <erinmr@gmail.com>

NASA for AQ Exceptional Event flagging

Westphal, Dr. Douglas L. <douglas.westphal@nrlmry.navy.mil> **Mon, Aug 11, 2008 at 4:37 PM**

To: rhusar@me.wustl.edu
Cc: erinmr@gmail.com

Rudolf B. Husar

Professor and Director

Center for Air Pollution Impact and Trend Analysis (CAPITA),

Washington University,

1 Brookings Drive, Box 1124

St. Louis, MO 63130

314 935 6099

Re: Proposal titled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule."

Dear Dr. Husar:

I acknowledge that I am identified by name as Collaborator to the investigation, entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule." that is submitted by Dr. Rudolf Husar to the NASA Research Announcement NNH08ZDA001N and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.

Sincerely,

Douglas L. Westphal

Letters from End-User Organizations

- R. Poirot, VT/RPO
- N. Frank, Federal EPA
- R. Neeley, EPA Region 4
- G. Percivall, OGC, GEOSS

VERMONT

Vermont Department of Environmental Conservation *Agency of Natural Resources*
Air Pollution Control Division
103 South Main Street, 3 South [phone] 802-241-3840
Waterbury, VT 05671-0402 [fax] 802-241-2590

Rudolf Husar
Professor of Mechanical Engineering
Washington University, Campus Box 1124
One Brookings Drive
St. Louis, MO 63130

August 8, 2008

Dear Dr. Husar:
I am very exited to learn of your pending NASA ROSES proposal to develop "Networks for Exceptional Event Decision Support (NEDS)". Having worked for a State air quality management agency for the past 30 years, I can attest to many outstanding air quality assessment projects and analysis tools you and the CAPITA staff have developed, which have directly enhanced the knowledge and capabilities of local, state, regional, national and international air quality management organizations. Many of these CAPITA projects and analysis tools have led in turn to the establishment of dynamic and continuing collaborative workgroups or networks of analysts, such as those that sprung up spontaneously to track an analyze past international aerosol transport events of Asian and Africa Dust, Mexican and Canadian forest fires, and regional stagnation or transport events of anthropogenic sulfate and nitrate aerosols or ozone..

The NEDS project will provide direct and much needed support to State and EPA Air Quality Management Agencies as they work to better understand and implement EPA's new Exceptional Event Rule (recently rendered much more critical by the newer and tighter daily standards for PM2.5 and ozone). In addition to this DSS support, I believe there will also be multiple "ancillary benefits" that result from NEDS, since in the course of identifying and documenting the relatively few events which are ultimately designated "exceptional" by EPA's current rule, we - the networked teams of State, EPA, NASA and academic air quality analysts - will inevitably come to a better understanding of the nature and causes of many air pollution events of varying causes, spatial and temporal extents, and degrees of severity. This will aid the development of improved emission inventories, improve estimates of air quality model boundary conditions, lead to better model performance evaluation criteria for dispersion and receptor models, and provide valuable insights to air quality forecasters and health effects researchers. State Agencies will be better able to focus State Implementation Plan (SIP) control strategies for PM, ozone and regional haze on sources which are "jurisdictionally controllable" at the State level; utilize regional, national or international forums for synoptic-scale transport events; and predict, recognize and track uncontrollable events which result from natural sources.

It is especially gratifying to see that NEDS will build directly on the existing DataFed infrastructure and utilize several related applications including the VIEWS, FASTNET and CATT tools which were specifically requested by and developed for the multi-state Regional Planning Organizations (RPOs). These "user designed" RPO data acquisition and analysis tools continue to attract and support a dynamic, collaborative network of empowered data analysts. By adding better connections to various NASA data products like GIOVANI (and associated NASA science expertise), and adding other perspectives such as quantitative estimates of intercontinental smoke, dust and sulfate impacts from the NAAPS global aerosol forecast model and regional impacts from the AIRPACT forecast model, the NEDS project will substantially enhance the power and use of these existing analysis tools and provide invaluable assistance to state and EPA Air managers for implementing the complex new Exceptional Events Rule. I look foreword to collaboration on this project in the near future.

Sincerely,

Richard L. Poirot

Richard L. Poirot
Air Quality Planner

To preserve, enhance, restore, and conserve Vermont's natural resources, and protect human health, for the benefit of this and future generations.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

August 7, 2008

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Rudolf Husar
Professor of Energy, Environmental and Chemical Engineering
Washington University
Campus Box 1124
One Brookings Drive
St. Louis, MO 63130

Dear Professor Husar:

The United States Environmental Protection Agency's (U.S. EPA) Office of Air Quality Planning and Standards (OAQPS) acknowledges receipt of information on your proposal to the NASA ROSES 2008 program entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule," and your request that we comment on the usefulness to air quality management of a project such as you are proposing to NASA.

Satellite data have been used by EPA since the mid-1970s for the documentation of regional-scale air pollution episodes over the eastern U.S. and continental plumes from North America, Africa, and Asia. More recently, satellite data, combined with ground measurements, have provided direct evidence of trans-continental transport of dust to the U.S. from Asia and Africa and of smoke from Mexico to the U.S. and Canada. In addition, these data combined with models, such as the Navy Aerosol Analysis and Prediction System model, have provided important evidence for intra-continental transport of dust, sulfates, and/or smoke. These findings have been referenced in EPA's Exceptional Event Rule and are now actively used by States and EPA in its implementation.

Specifically, the fusion of satellite-derived measurements from its multiple sensors, combined with ambient air pollution measurements, meteorological data, and modeled estimates have recently been shown to be very valuable to separate the complex sources of air pollution into anthropogenic and natural components and for understanding when events are allowed to be judged exceptional. Within the context of EPA regulations, this process allows us to use the appropriate data to judge violations of the National Ambient Air Quality Standards.

In OAQPS, we are finding that satellite data provide dramatic and easily understandable evidence of the long-range transport of particulate pollution, particularly those from forest fires and dust storms. However, the accessing and processing of the various satellite data for the

purpose of the Exceptional Event Rule, both by EPA and by State agencies, is rather time-consuming and does not occur on a routine basis. A "networked system" for one-stop data access would be a major step in making satellite information more readily available to the various end users. Such a data sharing network, augmented by tools for browsing, filtering, and aggregation of the various data sets, would enhance the knowledge-base needed for Exceptional Event Rule implementation.

As we have worked together on various projects over the years, I am aware that you and your associates at Washington University have been promoting the use of satellite data and applying satellite data to environmental problems since the mid 1970s. You and your project team, including Gregory Leptoukh, Shawn McClure, Joe Vaughn, Stefan Falke, Bret Schichtel, Doug Westphal, John McHenry, Sean Raffuse, and Ted Habberman, certainly have the knowledge, understanding, and abilities to perform the proposed work. The data networking facilities you have proposed should enhance the availability of satellite data to the air quality management community and allow more extensive use of satellite information by EPA and its State air pollution partners.

Sincerely,

Neil Frank
Senior Air Quality Data Advisor

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

AUG 1 3 2008

Rudolf B. Husar
Professor and Director
Center for Air Pollution Impact and Trend Analysis
Washington University
1 Brookings Drive, Box 1124
St. Louis, Missouri 63130

Dear Mr. Husar:

As Chief of the Air Toxics and Monitoring Branch, U.S. Environmental Protection Agency (EPA) Region 4, my staff has extensively used many of the air quality exceptional events Web-based tools that you have developed in cooperation with EPA's Office of Air Quality Planning and Standards. Since the promulgation of the exceptional events rule (40 CFR 50.14), our regional office has reviewed a large amount of $PM_{2.5}$ ambient air monitoring data that our state and local agencies have flagged as influenced by exceptional events. This process has required significant amounts of time and effort. We have found the tools you have developed to be very useful for the review and analyses of exceptional events.

From our evaluation of your proposed project, "Applying NASA Observations, Models and IT for Air Quality," we believe that it would be useful for our regional office in reviewing future exceptional events. A standardized set of tools can also be useful for state and local agencies as they prepare exceptional events data analyses and documentation. Such standardized Web-based tools would save time and resources, as well as provide a consistent basis for EPA's decisions on the exclusion of exceptional events data from National Ambient Air Quality Standards calculations.

Sincerely,

Van Shriner for

R. Douglas Neeley, Chief
Air Toxics and Monitoring Branch
Air, Pesticides and Toxics
Management Division

cc: Neil Frank, OAQPS

OGC®

Open Geospatial Consortium, Inc.
35 Main Street, Suite 5
Wayland, MA 01778-5037, USA
tel: +1 508-655-5858
fax: +1 508-655-2237
www.opengeospatial.org

Rudolf Husar
Professor of Energy, Environmental and Chemical Engineering
Washington University
Campus Box 1124
One Brookings Drive
St. Louis, MO 63130

Re: NASA ROSES 2008 Proposal

Dear Professor Husar,

The Open Geospatial Consortium, Inc (OGC®) acknowledges receipt of information on your proposal to the NASA ROSES 2008 program, entitled "Applying NASA Observations and Models for Air Quality: DSS for the Exceptional Event Rule" and your request that we comment on the usefulness to OGC and GEOSS Architecture of the project you are proposing to NASA.

Your AQ Network composed of data systems in NASA, EPA, NOAA, Navy and DataFed directly supports the GEOSS Architecture Implementation Pilot objective to "establish a broad set of persistent "operational, research and technical exemplars" services that support the GEOSS societal benefit areas. Your proposal would achieve making the Air Quality network plug-compatible with the GEOSS Common Infrastructure.

Your proposed AQ Network would interoperate with services provided by other GEO Members and Participating Organizations in support of a the GEOSS Societal Benefit Area for Health. Your plans for data flows harmonized by eliminating connectivity glitches and well-tested for persistency and robustness supports the GEOSS network and would be the basis for creating distributed, compound applications that are built by the combined effort of multiple organizations.

This proposal continues the exemplary work of Washington University and your partners in providing standards-based data access enabling the development of generic tools for data exploration, processing and visualization. Your efforts have support developments such as GEOSS as well as many others through your contributions to the development of the OGC Standards Baseline. Many of the GEOSS Interoperability Arrangements use OGC Standards. As you know the benefits of OGC standards-based service oriented architecture include that each tool is applicable to multiple datasets; creation of service orchestration for easy creation of new processing; and shared web-based tools to promote collaboration and communal data analysis.

Open Geospatial Consortium, Inc.
35 Main Street, Suite 5
Wayland, MA 01778-5037, USA
tel: +1 508-655-5858
fax: +1 508-655-2237
www.opengeospatial.org

Results of the NASA ROSES 2008 project can be applied to the further development and maturation of OGC's open standards. Successful implementation of the AQ network as persistent exemplars can a basis for OGC Best Practices for use by the wider community.

The OGC is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial and location based services. The 369 companies, government agencies and universities participating in the OGC consensus processes provide the venue to deploy the results of research into the "geo-enable" Web, wireless and location-based services, and mainstream IT.

Sincerely yours,

(signed)
George Percivall
Chief Architect
Open Geospatial Consoritum

Budget Justification:

Personnel
The PI, Rudolf B. Husar, will be responsible for the research described in this proposal. Rudolf B. Husar is Professor of Energy, Environmental and Chemical Engineering and Director of the Center of Air Pollution and Trend Analysis (CAPITA) at Washington University in St. Louis. He will supervise one full time graduate research assistant (GRA) in all aspects of his or her studies. Husar's annual effort devoted to this project is quantified in the budget detail.

Funds are requested to provide wages for a GRA's each year. $26,914 is budgeted (for year one) to support the GRA's and is a competitive rate necessary to attract a qualified student.

A three and one-half annual increase is budgeted for faculty salaries, three percent for the PI and 5% annually for each of the GRA's. This increase rate is consistent with the University's policy.

Fringe Benefits
The PI, and Co-PI qualify for University benefits which include contributions to FICA, 403B retirement plan, health, and disability. The Postdoctoral Research Assistant qualifies for all University benefits, except the 403B retirement plan. The salary budget includes fringe benefit costs. The GRAs are not eligible for University benefits.

Travel

First year total of $7,000 is itemized as follows: An annual trip to national AGU, San Francisco, CA
a. RT coach airfare $750
b. Registration Fee; $420
c. Hotel @ IRS per diem rate of $140/night: $700
d. Meal and IE @IRS per diem rate of $46/day; $230

One trip to the European Geophysical Union Annual Mtg,, Vienna, AUT (total cost $3630, one half of the cost ($1,815 charged to the proposal)
a. RT coach airfare $1,600
b. Registration fee; $800
c. Hotel @ IRS per diem rate of $196/night: $980
d. Meal and IE @IRS per diem rate of $46/day; $230

One trip to a national Federation of Earth Science Information Partners (ESIP) conference at t/b/n
a. RT coach airfare; $600
b. Registration fee; $300
c. Hotel @ IRS per diem rate of $140/night: $240
d. Meal and IE @IRS per diem rate of $46/day; $130

One trip to the EPA Coordination meeting RTP, NC (2 person trip)
a. RT coach airfare $400 x2 = 800
b. Hotel @ IRS per diem rate of $160/nightx 2 nights $320x 2=640
c. Car rental 200
d. Meal and IE @IRS per diem rate of $46/day; $92x2=$184

Supplies
To cover cost of software procurement and required small hardware for maintaining network, servers, and workstations, as well as purchase of books and PC journals; $3,500.

Consultants
Kari Hoijarvi, programming consultant, was instrumental in CAPITA programming for the last ten years. Hoijarvi will be responsible for programming data tools and applications.

Intragency Transfer
Interagency transfer to NASA GIOVANNI Group will provide key satellite data to core network. Covers Senior Scientist, Greg Leptoukh.

Subcontracts
VIEWS subcontract will support Shawn McClure in establishing connections to core network.

Washington State University subcontract will support Joe Vaughn in establishing connection to core network and participating in air pollution event analysis.

Baron Advanced Meteorological Services will be participating in core network by providing regional scale air quality simulation and forecasting.

Other Direct Costs
$3,100 is requested each year computer network, support and management charges as well as publication charges.

Indirect Cost
The Indirect Cost rate used for this proposal is 52.0% MTDC, approved 06/07/2005 by the DHHS. The MTDC for this proposal is $1,021,856, and corresponding indirect cost is $531,365.

Facilities and Equipment
Year 1: To cover the cost of a computer server with accessories; Year 2: to cover the cost of 2-3 workstations and laptops; Year 3: To cover the cost of server and workstations upgrades for technology development phase of the project.

Curriculum Vitae

CAPITA Group:

- R. Husar
- K. Hoijarvi
- E. Robinson

Co-Is:

- G. Leptoukh
- S. McClure
- J. McHenry
- J. Vaughan

Collaborators:

- S. Falke
- R. Haberman n
- S. Larkin
- B. Schichtel
- D. Westphal

Biographical Sketch

Rudolf B. Husar

Center for Air Pollution Impact and Trend Analysis (CAPITA), Campus Box 1124,
Washington University, St. Louis, MO 63130-4899.
Phone: (314) 935-6099 Fax: (314) 935-6145, e-mail: rhusar@me.wustl.edu

a. Professional Preparation

1962–66 Dipl. Ing. Mechanical Engineering, Technical University, Berlin, FRG.
1966-71 Ph.D. Mechanical Engineering, U. of Minnesota, Minneapolis, MN, US.
1971-73 Post-Doctoral Fellow, California Institute of Technology, Pasadena, CA, US.

b. Appointments

1979-Present Director, Center CAPITA, Washington University St. Louis, MO
1976-Present Professor, Energy, Environmental and Chemical Eng., Washington U. St. Louis, MO
1976-77 Visiting Professor, Meteorological Institute, Stockholm U., Sweden
1973-76 Associate Professor, Mechanical Engineering, Washington U. St. Louis, MO

c. List of publications

Husar, R.B., Poirot R.L., DataFed and FASTNET: Tools for Agile Air Quality Analysis, Environmental Managers, Air & Waste Management Association, September 2005, 39-41, 2005.

C. Blachard, R. Husar, R. Vet, T. Dann, G. Raga, P. Solomon, E. Vega, Spatial and Temporal Characterization of Particulate Matter, In: McMurray, P.H., M.F. Sheperd, J.S. Vickery, eds. Particulate Matter Science for Policy Makers. A NARSTO Assessment, Cambridge University Press, (2004).

Husar, R.B., Intercontinental Transport of dust - a historical and recent observational evidence. In: Intercontinental Transport of Air Pollution, A. Stohl, Ed. The Handbook of Environmental Chemistry, 4G, Springer Verlag Berlin, Heidelberg, New York (2004).

Heintzenberg, J., F. Raes, S.E. Schwartz, I. Ackermann, P. Artaxo, T.S. Bates, C. Benkovitz, K. Bigg, T. Bond, J.L. Brenguier, F.L. Eisele, J. Feichter, A.I. Flossmann, S. Fuzzi, H.F. Graf, J.M. Hales, H. Herrmann, T. Hoffmann, B. Huebert, R.B. Husar, R. Jaenicke, B. Kärcher, Y. Kaufman, G.S. Kent, M. Kulmala, C. Leck, C. Liousse, U. Lohmann, Tropospheric Aerosols. In: Brasseur, G.P., R.G. Prinn, A.A.P. Pszenny, eds. Atmospheric Chemistry in a Changing World, The IGBP Series, Springer, (2003).

Falke, S.R., R.B. Husar and B.A. Schichtel, Fusion of SeaWiFS and TOMS Satellite Data with Surface Observations and Topographic Data During Extreme Aerosol Events, *J. Air Waste Manage. Assoc.*, 51, 1579-1586 (2001).

Schichtel, B.A., R.B. Husar, S.R. Falke, and W.E. Wilson, Haze Trends over the United States, *Atmos. Environ.*, 35, 5205-5210 (2001).

Husar, R.B., D. M. Tratt, B. A. Schichtel, S. R. Falke, F. Li D. Jaffe, S. Gassó, T. Gill, N. S. Laulainen, F. Lu, M.C. Reheis, Y. Chun, D. Westphal, B. N. Holben, C. Gueymard [1] I. McKendry, N. Kuring, G. C. Feldman, The Asian Dust Events of April 1998. (http://capita.wustl.edu/Asia-FarEast/) *J. Geophys. Res.*, 106(D16), 18317-18330 (2001).

Husar R. B., J. D. Husar and L. Martin, Distribution of continental surface aerosol extinction based on visual range data, http://capita.wustl.edu/CAPITA/CapitaReports/GlobVisIGAC/AEGlobVisHTM.htm) *Atmos. Environ.* 34, 5067-5078 (2000).

Lefohn, A. S., J. D. Husar and R.B. Husar, Estimating historical anthropogenic global sulfur emission patterns for period 1850-1990 (1999). http://capita.wustl.edu/CAPITA/CapitaReports/GlobSEmissions/GlobS1850_1990.htm *Atmos. Environ.* 33, 3435-2444 (1999).

Husar R.B., J.M. Prospero and L.L. Stowe, Characterization of Tropospheric Aerosols over the Oceans with the NOAA Advanced Very High Resolution Radiometer Optical Thickness Operational Product, *J. Geophys. Res.* 102, D14, 16889-16909 (1997).

Activities

Professionally, Husar works on the interface between atmospheric science and environmental informatics, switching between the two in ten-year cycles. In 2005, he is finishing a cycle of software development which resulted in the DataFed data sharing and analysis system. In conducting this work, he interacted synergistically with others interested in Earth Science informatics. As a lead of the NASA Data Systems Workgroup, Web services subgroup, he has coordinated the development of a Web services roadmap. Husar has promoted openness and inclusiveness in his activities as part of the International Global Atmospheric Chemistry (IGAC) program. For the past four years, Husar was teaching a course in Environmental Informatics with focus on information engineering, i.e. the flow, driving forces and resistances of information flow and processing. He encourages teamwork and the use of the web as a communication/data-sharing medium for the class. Husar has long experience in the effective use of graphics in data exploration, analysis and presentation. In 1987, he and his co-workers have designed the data exploration software Voyager that is being used by many atmospheric data analysts worldwide. He co-developed a new 3D rendering algorithm for clouds. The synthetic 3D globe images (using data from four different satellites) generated by the new method vividly illustrates the Earth as an interactive system of air, land and water. The 3D Globe images were used by the National Geographic, Scientific American, five book/journal covers, NASA posters and many other public outreach efforts.

Member, Hungarian Academy of Sciences, 1998
Associate Editor, Atmospheric Systems, The Scientific World, 2001-present
Member of Editorial Board, Environmental Monitoring and Assessment, 2000-present
Past Executive Editor, Atmospheric Environment
Chair WMO Panel on Global Aerosol Data System, Chair, 1991, 2006
WMO Panel on Space Observations of Tropospheric Aerosols, Group Leader, 1990

Collaborators

Collaborators: *Y. Chun, Seoul, South Korea; D. DuBois, Santa Fe, NM, USA; B. A. Schichtel and W. C. Malm, Ft. Collins, USA; R. J. Frouin, La Jolla, CA, USA; T. Gill, Lubbock, TX, USA; B. N. Holben, G. C. Feldman, C. McClain, and N. Kuring, Greenbelt, MD, USA; D. Jaffe and S. Gassó, Seattle, WA, USA; J. Prospero, Miami, FL, USA; M.C. Reheis, USA; D. M. Tratt, Pasadena, CA, USA; J. Merrill, Kingston, RI, USA; K. Sassen, Salt Lake City, UT, USA; N. Sugimoto, Iburaki, Japan; F. Vignola, Eugene, OR, USA; D. Westphal, Monterey, CA, USA; W. E. Wilson, Research Triangle Park, NC, USA*

Thesis advisor and Postgraduate sponsor*: Dr. S. R. Falke, U. S. Environmental Protection Agency, Office of Environmental Information, Washington, DC; Dr. B. A. Schichtel, NPS Air Resources Division, CIRA, Colorado State University, Ft. Collins, Dr. Fang Li, University of California, La Jolla, CA, Marin Bezic, MSc., Microsoft, Redmond,WA.*

15 additional Ph.D. and Masters Theses and 21 post-doctoral associates and science visitors since 1973.

Biographical Sketch

Kari Hoijarvi

Center for Air Pollution Impact and Trend Analysis (CAPITA), Campus Box 1124,
Washington University, St. Louis , MO 63130-4899.
Phone: (314) 935-6099 Fax: (314) 935-6145, e-mail: hoijarvi@me.wustl.edu

Professional Preparation

1981-1988 Dipl. Eng., (equivalent to MSc) Power Engineering, University of Lappeenranta, Finland

Appointments

2004-present, consultant Mouse Paint Software, LLC
2001-2004 Research Associate, CAPITA
1998-2001 Software Design Engineer, Vaisala Oyj.Software
1995-1998 Software Design Engineer, Microsoft Corp.
1992-1995 Research Associate, CAPITA
1988-1992 Software Design Engineer, Nokia Research Center

List of publications most closely related (5) and other significant (5)

Kari Höijärvi, Diploma Thesis: Computer Aided Machining of Turbomachine Blades, Lappeenranta University of Technology, UDK: 681.3:681.323:62-135 (1988).

Husar, R.B., K. Hoijarvi, J. Colson, and S. Falke. Design of the Voyager Services and Browsing System, http://capita.wustl.edu/voyager/Reports/DvoyDesign.htm
Voyager Browser: http://capita.wustl.edu/voyager, CAPITA Publication 02-12 (2002).

Husar, R.B., K. Hoijarvi, J. Colson, Access, Homogenization and Exploration of Heterogeneous Data Distributed over the Web, http://capita.wustl.edu/VoyServices/Reports/DVOy020608.doc, CAPITA Publication 06-08 (2002).

Research Activities

Vaisala http://www.vaisala.com, Helsinki, Finland, Position: Senior Software Engineer:
Projects: Midas IV airport weather system.Architect and lead developer for MetMan data collection network; Tools : C++, VB, Windows NT, MSMQ, ADO

Microsoft, Redmond, WA, position: Software Design Engineer
Projects: Outlook 97, 98 and Exchange 4.5: Tools : C++, MAPI, Java

Washington University http://capita.wustl.edu/ Saint Louis, MO, Position: Research Engineer
Projects: Visualization of air pollution data. Tools : C++, VB, Win 3.1 and NT 3.51

Nokia Research Center, Helsinki, Finland, Position: Software Design Engineer
Projects: Visual Planner project management tool; Tools : C, Windows 2.0 - 3.1

Northern Research and Engineering Corp.Woburn, MA, Position: Intern
Projects: M.Sc. thesis work, http://www.conceptseti.com/max_ab.htm Tools : Fortran, VAX/VMS. This is undoubtedly the most difficult program I have ever written, a mathematically challenging research project.

Goals: Getting better in Software Engineering. I follow the old well known truth from the academic world: if you want to know a topic well, teach a class about it. I have lectured at Nokia Research Center about Aspect Oriented Programming with Java and several classes at www.tieturi.fi about software quality, process improvement and subcontracting. And of course having life with my wife and three children. Fluent English and Finnish, a little Swedish and German

Biographical Sketch

Erin M. Robinson

Center for Air Pollution Impact and Trend Analysis (CAPITA), Campus Box 1124,
Washington University, St. Louis, MO 63130-4899.
Phone: (314) 369-9954 Fax: (314) 935-6145, e-mail : emr1@wustl.edu

Professional Preparation

2006-Present	Washington University in St. Louis, Ph.D. Candidate in Energy, Environmental & Chemical Engineering, St. Louis, MO	
2002-2006	Washington University in St. Louis, B.Sc., Chemical Engineering	St. Louis, MO

Activities

Erin has worked with her advisor, Professor Husar at the interface between environmental informatics and atmospheric science for the past four years. Specifically, she has focused on two areas: (1) Aerosol event analysis using a combination of satellite and surface sensors as well as model data; (2) The use of new web technology for open collaborations in air pollution-related research projects.

With these focus areas she has assisted Professor Husar on multiple projects. Over the past two years Erin has been involved in the development and use of new collaborative web technologies and has worked to implement a wiki website for CAPITA, as well as improve collaboration in the projects CAPITA is involved in. Current projects include continued development and improvement of an AOT extraction algorithm using SeaWiFS satellite data. Using the derived AOT data from SeaWiFs as well as other satellite, surface and model data, a few air pollution use cases have been analyzed.

Over the past two years, Erin has been a teaching assistant for Professor Husar's course, Sustainable Air Quality. In that role she has helped plan class assignments and activities, implemented a class wiki website and facilitated learning through collaboration.

Recent Publications:

Robinson, E., Husar, RB. Enabling Tools and Methods for International, Inter-disciplinary and Educational Collaboration, Abstract # IN41A-02, Talk at American Geophysical Union, Spring Meeting 2008

Robinson, E. M.; Kieffer, M.; Kovacs, S.; Falke, S. R.; Husar, R. B. Mashup of Tools through Interoperability Standards RSS, RDF, KML and XSL, Abstract #IN44A-03, Talk at American Geophysical Union, Fall Meeting 2007

Robinson, E., Husar, RB. Aerosol Characterisation Using the SeaWiFS Sensor and Surface Data, Abstract # A33C-0929, Poster at American Geophysical Union, Fall Meeting 2005

Husar, R.B., Raffuse, S.M., Robinson, E.M. (2004) Co-Retrieval of Aerosol and Surface Reflectance using SeaWiFS data, 2000-2002, Paper # 96, Presented at the A&WMA Annual Conference, Indianapolis, IN, 2004

Gregory Leptoukh, Ph.D. (Co-Investigator)

Physical Scientist / Science Data Manager

Code 610.2, NASA Goddard Space Flight Center, Greenbelt, MD 20771

Relevant Experience: Over 30 years of experience in remote sensing, multi-sensor data intercomparison, science data analysis, and management, development of data systems and tools, physics, non-linear mathematics, data pattern recognition, and Monte-Carlo simulations.

Education:

1985 Ph.D. Cosmic Rays Physics, Tbilisi State University and Moscow State University, USSR

1975 M.S. Theoretical Physics, Tbilisi State University and Moscow Institute of Theoretical and Experimental Physics, USSR

Professional Experience:

NASA GSFC: Science Data Manager, 2003 – Present: Leads all aspects of science support elements related to EOS Terra (MODIS), Aqua (MODIS, AIRS), Aura (OMI, MLS, HIRDLS), and heritage missions; directs design and development of online science data analysis, data access and manipulation tools; works on statistical aspects of multi-sensors data fusion.

Principal Investigator for the NASA supported project "NASA Earth Sciences Data Support System and Services for the Northern Eurasia Earth Science Partnership Initiative".

He is also Co-I for four NASA projects related to data fusion, online analysis and visualization of atmospheric data/

Previous Positions:

Contractor: Remote sensing data processing and science support, 1996 – 2002: Provided and then managed science data related support of remote sensing missions at NOAA and NASA.

Academia: Research in Physics, 1976 – 1996: Cosmic Rays, High-Energy, and Molecular Dynamics Physics; Non-linear Mathematics (USSR and at the North Carolina State University).

Professional Activities:	Member, IEEE Geosciences and Remote Sensing Society
	Member, American Geophysical Union
Awards:	Nine NASA group awards

Recent Relevant Publications:

Stephen W. Berrick, **Gregory Leptoukh**, John Farley, Hualan Rui, 2008. Giovanni: A Web Services Workflow-Based Data Visualization and Analysis System, IEEE Trans. on Geoscience and Remote Sensing, accepted

Savtchenko, A., Kummerer, R., Smith, P., Gopalan, A., Kempler, S., and Leptoukh, G., 2008. A-Train Data Depot - Bringing Atmospheric Measurements Together, IEEE Trans. on Geoscience and Remote Sensing, accepted

Shen,S., Leptoukh, G., Acker, J., Yu, Z., Kempler, S., 2008. Seasonal Variations of Chlorophyll-a Concentration in the Northern South China Sea, Geoscience and Remote Sensing Letters, 5, pp. 315-219

Acker, J.G., Gregory Leptoukh, Suhung Shen, Tong Zhu, and Steven Kempler, 2008. Remotely-sensed chl a observations of the northern Red Sea indicate significant annual variability and influence of coastal reefs, Journal of Marine Systems, 69, 191-204.

Leptoukh, G., Csiszar, I., Romanov, P., Shen S., Loboda T., Gerasimov, I., 2007. NASA NEESPI Data Center for Satellite Remote Sensing Data and Services, Global and Planetary Change, Environ,Res. Lett. 2, 045009, doi:10.1088/1748-9326/2/4/045009

Liu, Z., H. Rui, W. L. Teng, L. S. Chiu, G. G. Leptoukh, and G. A. Vicente, 2007. Online visualization and analysis: A new avenue to use satellite data for weather, climate and interdisciplinary research and applications, in Measuring Precipitation from Space - EURAINSAT and the future, Advances in Global Change Research, 28, 549-558

Xin-Min Hua, J. Pan, D. Ouzounov, A. Lyapustin, Y. Wang, K. Tewari, Greg Leptoukh, B. Vollmer, 2007. A Spatial Pre-Screening Technique for Earth Observation Data, Geoscience and Remote Sensing Letters, 4, 152-156, doi: 10.1109/LGRS.2006.886421

J.G. Acker and G. Leptoukh, 2007. Online Analysis Enhances Use of NASA Earth Science Data, EOS, Transactions of American Geophysical Union, 88, 14

Shawn McClure

Software Engineer
Cooperative Institute for Research in the Atmosphere (CIRA)
Colorado State University, Fort Collins, CO

Professional Preparation

B.S. Computer Science, *summa cum laude*, Southwest Baptist University, 1990
B.S. Mathematics and Physics, *summa cum laude*, Southwest Baptist Univ., 1991

Professional Preparation

Mr. McClure has worked as a software engineer to develop environmental data management systems since 1992. Currently, he works for the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University to develop and maintain a relational database management system to import, verify, and manage national air quality data as well as an enterprise-level suite of online software tools for visualizing, analyzing, and disseminating the data on the web. During his current appointment he has worked closely with scientists and researchers to develop standards and best practices for managing air quality data and metadata and presenting this data on the web.

Mr. McClure has also recently worked for Crocker Nuclear Laboratory at the University of California, Davis to develop a relational database management system for managing the aerosol sampling data, site metadata, instrument calibrations, operational and historical logs, and analysis metadata for the IMPROVE monitoring network, and to implement a system of online visualization and analysis tools for performing quality assurance and validation of the data.

Recent Publications and Presentations

McClure, S.E., 2008: VIEWS/TSS: An Integrated Systems Solution for Air Quality and Regional Haze Planning. *AWMA 2008, Moab, UT*

Shankar, U., S.E. McClure: Improving an Air Quality Decision Support System through the Integration of Satellite Data with Ground-based, Modeled, and Emissions Data. *NASA ROSES Proposal (Awarded) 2008*

McClure, S.E., 2008: Integrated Decision Support: The Visibility Information Exchange Web System (VIEWS) and the WRAP Technical Support System (TSS). *EPA Data Summit 2008, Research Triangle Park, NC*

Representative Online Products

The Visibility Information Exchange Web System (VIEWS): http://vista.cira.colostate.edu/views

The WRAP Technical Support System (TSS): http://vista.cira.colostate.edu/tss

The Air Toxics Data Archive (ATDA): http://vista.cira.colostate.edu/atda

JOHN N. MCHENRY
Chief Scientist; Baron Advanced Meteorological Systems
920 Main Campus Drive, NCSU Centennial Campus, Suite 101, Raleigh, NC 27606
Phone: (919) 424-4443; *Fax*: (919) 424-4401, john.mchenry@baronams.com

ACADEMIC BACKGROUND

B.S**.** Physics and Mathematics, DePauw University, 1977 (**Summa Cum Laude, Phi Beta Kappa**)
M.Sc. Meteorology, Massachusetts Institute of Technology, 1980 **Advisor:** *Dr. Edward N. Lorenz*)
Ph. D. Meteorology, North Carolina State University (anticipated 2010).

PROFESSIONAL EXPERIENCE

2003-present	**Chief Scientist**, Baron Advanced Meteorological Systems, RTP, NC.
2003-present	**Visiting Scholar**, Marine, Earth and Atmospheric Sciences Dept. NCSU, Raleigh, NC
1998-present	**Research Affiliate**, State Climate Office of North Carolina, NC St. Univ., Raleigh, NC.
1992-2002	**Research Meteorologist** MCNC-North Carolina Supercomputing Center, RTP, NC.
1987-1992	**Meteorologist**, **Senior Member of Technical Staff**, Comp Sci Corp, RTP, NC
1982-1987	**Director of Youth Ministry**, Our Lady of Lourdes Church, Raleigh, NC.
1980-1981	**Staff Meteorologist,** GCA/Technology Division, Bedford, MA.
1977-1980	**Research Assistant,** Dept. of Meteorology, MIT.
1976-1977	**Intern and Senior Undergraduate Research Associate,** Argonne Nat'l Lab.

BIOGRAPHICAL SKETCH

John McHenry is Chief Scientist at Baron Advanced Meteorological Systems (BAMS), a subsidiary of Baron Services, Inc. (BSI, http://www.baronservices.com), where he leads the operational numerical weather/air quality prediction team and guides the scientific direction of the company. He holds a co-appointment as Visiting Scholar in the Dept. of Marine, Earth, and Atmospheric Sciences at North Carolina State University, where he is in residence. BAMS currently supplies a multitude of state and local agencies with numerical air quality predictions, providing decision support for operational air quality forecasting (AQF). He is currently PI on a NASA Earth Science Applications Program grant enabling assimilation of remotely-sensed aerosol observations into the AQF decision support system. He was the first to supply a broadcast television station with on-air graphical air quality predictions based on the output from a photochemical model running in real-time. That has now expanded to include more than 200 television stations. He recently completed a role as a NOAA PI implementing the SMOKE emissions processing/modeling system and CMAQ aerosol module into the WRF-Chemistry model. His operational MAQSIP-RT (and more recently CMAQ) forecasting system has been widely applied to support field programs, beginning with TXAQS 2000, extending through the three ICARTT-related programs, and most recently during TXAQS2. During 2001-2002, he was a lead modeler in the NOAA "early-start" chemical weather forecasting initiative, and represented the private-sector on the NOAA-sponsored Asian Regional Weather Research Forecast (WRF) Model Meeting in Beijing, China. He is a member of the WRF-Working Group-11 and participated with the USWRP Prospectus Development Team-11 specialty workshop on air quality forecasting. He has recently co-authored two expert panel reports recommending the role of the USEPA in the GEOSS and synergistic US air quality forecasting activities. He collaborates widely, has more than 10 refereed journal publications, and has over 30 other publications including conference papers, reports, federal documents, and parts of books.

ACTIVITIES and AWARDS

WRF-Working Group 11; USWRP Invited Workshop on Air Quality Forecasting for PDT-11; PSU/NCAR Mesoscale Model Users' Workshop Session Chair; MM5 User's Advisory Committee; AMS Annual Meeting E-Theatre Presenter; AMS Atmospheric Chemistry Specialty Meeting Session Chair; American Meteorological Society Atmospheric Chemistry Committee (Term: 1999-2002); American Meteorological Society Committee on Meteorological Aspects of Air Pollution (Term: 2004 – present).

JOHN N. MCHENRY (2)

JOURNAL AND PROPOSAL REVIEWS

Journal of Applied Meteorology

Monthly Weather Review

PROFESSIONAL AFFILIATIONS

American Meteorological Society

SELECTED REFEREED PUBLICATIONS

Mathur, R., U. Shankar, A. Hanna, M.T. Odman, J.N.McHenry, C.J. Coats, Jr., K. Alapaty, A.Xiu, S. Arunachalam, D.T. Olerud, Jr., D.W. Byun, K.L. Schere, F.S. Binkowski, J.K.S. Ching, R.L. Dennis, T.E.Pierce, J.E. Pleim, S.J. Roselle, and Jeffrey O. Young, The Multiscale Air Quality Simulation Platform (MAQSIP), 2005: Initial Applications and Performance for Tropospheric Ozone and Particulate Matter. *Jou. Geophys. Res.* ***110****, D13308, doi:1029/2004JD004918, 2005*

McKeen, S., J. Wilczak, G. Grell, I. Djalalova, S. Peckham, E.-Y. Hsie, W. Gong, V. Bouchet, S. Menard, R. Moffet, J. McHenry, J. McQueen, Y. Tang, G.R. Carmichael, M. Pagowski, A. Chan, and T. Dye, 2005: Assessment of an ensemble of seven real-time ozone forecasts over Eastern North America during the summer of 2004. *J. Geophys. Res*., doi 10.1029/2005JD005858, in press.

Pagowski, M., G.A. Grell, S.A. McKeen, D. Devenyi, J.M. Wilczak, V. Bouchet, W.Gong, J. McHenry, S. Peckham, J. McQueen, R. Moffet, and Y. Tang, 2005: A simple method to improve ensemble-based ozone forecasts. *Geo. Res. Let.* ***32****, L07814 doi:10.1029/2004GL022305,2005*

Eder, B., D. Kang, A. Stein, J. McHenry, G. Grell, and, S. Peckham, 2005: The New England Air Quality Forecasting Pilot Program: Development of an evaluation protocol and performance benchmark. *Jou. Air and Waste Man Assoc*., **55**, 20-27.

McHenry, J.N., W.F. Ryan, N.L. Seaman, C.J. Coats Jr., J. Pudykeiwicz, S. Arunachalam, and J.M. Vukovich, 2004: A real-time eulerian photochemical model forecast system: overview and initial ozone forecast performance in the NE US corridor. *Bull. Amer. Met. Soc.* **85**, 4, 525-548

Hogrefe, C., S.T. Rao, P. Kasibhatla, G. Kallos, C.J. Tremback, W. Hao, D. Olerud, A. Xiu, J. McHenry, and K. Alapaty, 2001: Evaluating the performance of regional-scale photochemical modeling systems: Part I – meteorological predictions. *Atmos. Environ*. **35**, 4159-4174.

Hogrefe, C., S.T.Rao, P. Kasibhatla, W. Hao, G. Sistla, R. Mathur, and J. McHenry, 2001: Evaluating the performance of regional-scale photochemical modeling systems: Part II: ozone predictions. *Atmos. Environ*. **35**, 4175-4188.

McHenry, J.N. and R.L. Dennis, 1994: The relative importance of oxidation pathways and clouds to atmospheric ambient sulfate production as predicted by the Regional Acid Deposition Model (RADM). *Jou. Appl. Met.* **33**, 7, 890-905.

McHenry, J.N., Binkowski, F.S., Chang, J.S., and D. Hopkins, 1992. The tagged species engineering model. *Atmos. Environ.* **26A**, 8, 1427-1443.

SELECTED REPORTS/GRANT FINAL REPORT

McHenry, J. N. and W.F. Dabberdt, 2005: Air quality and meteorological monitoring strategies to advance air quality modeling and its application to operational air quality forecasting. *Final Report.* National Exposure Research Lab, Office of Research and Development, US Environmental Protection Agency, RTP, NC 27711, EPA/600/R-05-154, 80pp.

Dabberdt, W.F., and J.N. McHenry, 2004: Global Earth Observation System (GEOS): System Capabilities and the role for the US EPA: Recommendations of a community panel. *Final Report.* National Exposure Research Lab, Office of Research and Development, US Environmental Protection Agency, RTP, NC 27711, EPA/600/R-05-009, 62pp.

McHenry, J., and C.D. Peters-Lidard, 2002: Assimilation of remotely-sensed data into a coupled hydrological/meteorological modeling system using parallel techniques. *Grant Final Report*. EPA STAR Grant CR825210-01-0, USEPA National Center for Environmental Research and Quality Assurance (NCERQA) Grants Administration Division (3903R) 401 M Street, SW Washington, DC 20460, 79pp.

Biographic Sketch

JOSEPH VAUGHAN
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Laboratory for Atmospheric Research
Department of Civil & Environmental Engineering
Washington State University
Pullman, WA 99164-2910

RESEARCH INTERESTS

Atmospheric pollutant transport and dispersion studies, air quality modeling, and regional windblown dust air quality modeling.

EDUCATION

2000	Ph.D.	Washington State University	Civil Environmental Engineering
1979	M.S.	Duke University	Environmental Studies
1975	A.B.	Vassar College	Astronomy

PROFESSIONAL EXPERIENCE

2003 – Present Research Assistant Professor, Laboratory for Atmospheric Research, Department of Civil & Environmental Engineering , WSU.

2000 – 2003 Postdoctoral Researcher, Laboratory for Atmospheric Research, Department of Civil & Environmental Engineering, WSU.

SELECTED PUBLICATIONS

Chen, J., J. Vaughan, J. Avise, S. O'Neill, and B. Lamb (2008), Enhancement and evaluation of the AIRPACT ozone and PM2.5 forecast system for the Pacific Northwest, *J. Geophys. Res.*, 113, D14305, doi:10.1029/2007JD009554.

O'Neill, S. M., N, K. Larkin, J. Hoadley, G. Mills, J. K. Vaughan, R. Draxler, G. Rolph, M. Ruminski, S. A. Ferguson, Real-Time Smoke Prediction Systems, a book chapter in *Symposium on Forest Fires and Air Pollution Issues*, Elsevier, (2008) in press.

Rahul Jain, Joseph Vaughan, Kyle Heitkamp, Charleston Ramos, Candis Claiborn, Maarten Schreuder, Mark Schaaf and Brian Lamb, Development of the ClearSky Smoke Dispersion Forecast System for Agricultural Field Burning in the Pacific Northwest, *Atmospheric Environment*, **41**:32, 6745-6761, 2007.

Vaughan, J., B. Lamb, R. Wilson, C. Bowman, C. Figueroa-Kaminsky, S. Otterson, M. Boyer, C. Mass, M. Albright, J. Koenig, A. Collingwood, M. Gilroy, N. Maykut, (2004). A Numerical Daily Air Quality Forecast System for the Pacific Northwest, *Bulletin Amer. Meteorol Soc.*,85, 549-561.

Snow, J.A., J.B. Dennison, D. A. Jaffe, H.U. Price, J.K. Vaughan, and B. Lamb, 2003. Aircraft measurements of air quality in Puget Sound: Summer 2001, *Atmos. Environ*. 37, 4019-4032.

Mass, C.F., M. Albright, D. Ovens, R. Steed, E. Grimit, T. Eckel, B. Lamb, J. Vaughan, K. Westrick, P. Storck, B. Coleman, C. Hill, N. Maykut, M. Gilroy, S. Ferguson, J. Yetter, J. M. Sierchio, C. Bowman, D. Stender, R. Wilson, and W. Brown, 2003. Regional environmental prediction over the Pacific Northwest, *Bulletin Amer. Meteorol. Soc*., 84, 1353-1366.

Vaughan, J.K., C. Claiborn, D. Finn, 2001. Dust event over the Columbia Plateau. J. Geophys. Res. 106, 18,381-18,402.

Claiborn, C., B.K. Lamb, A. Miller, J. Beseda, B. Clode, J. Vaughan, L. Kang, and C. Newvine (1998). Regional measurements and modeling of windblown agricultural dust: The Columbia Plateau PM_{10} Program, *J. Geophys. Res.* 103, 19753-19768.

Biographic Sketch

Stefan R. Falke

Geospatial Intelligence Operating Unit
Northrop Grumman Corporation IT, Geospatial Intelligence Group
Suite 1740, 1010 Market Street, St. Louis, MO 6310
Phone: (314) 259-7908, e-mail: stefan.falke@ngc.com

Department of Energy, Environmental, and Chemical Engineering
Washington University in St. Louis
Campus Box 1180, One Brookings Drive, St. Louis, MO 63130
e-mail: stefan@wustl.edu

Professional Appointments

2005–	Manager, Geospatial Information Services for Energy & Environment, Northrop Grumman Corporation IT, St. Louis, MO
2002–	Research Assistant Professor, Department of Energy, Environmental and Chemical Engineering, Washington University
2000–2002	American Association for the Advancement of Science (AAAS) Science and Technology Policy Fellow, US Environmental Protection Agency, Office of Environmental Information
1999–2000	Research Associate, Center for Air Pollution Impact and Trend Analysis, Washington University

Education

1999	D.Sc. in Environmental Engineering, Washington University
1993	M.S. in Engineering and Policy, Washington University
1992	B.A. in Physics, Lehigh University

Selected Research Projects

1/2008–	PI, *PULSENet Sensor Web*, Northrop Grumman Independent Research and Development
9/2006–8/2009	PI, *Sensor-Analysis-Model Interoperability Technology Suite*, NASA Earth Science Technology Office
4/2005–3/2008	PI, *Cyberinfrastructure for Air Quality Management: Networked Data & Tools for Emissions Analyses & Applications*, EPA Office of Air and Radiation
11/2004–10/2009	co-PI, *Application of Earth Science Enterprise Data and Tools to Particulate Air Quality Management*, NASA

Professional Service

Co-chair of the Earth Science Information Partners Federation (ESIP) Air Quality Cluster

Co-chair of the Open Geospatial Consortium Earth Observation and Natural Resources & Environment Workgroup

Proposal Reviewer for the *National Science Foundation, National Aeronautics and Space Administration*

Manuscript Reviewer for *Atmospheric Environment, Journal of the Air & Waste Management Association, Journal of Applied Meteorology, Journal of Geophysical Research*

Co-chair *Decision Support Systems, Air & Waste Management Association Aerosol and Atmospheric Optics: Visual Air Quality and Radiation Balance Conference , 2008*

Co-chair *Web Based Information Systems, EPA International Emission Inventory Conference, 2006*

Co-chair *Decision Support Systems for Wildland Fire Management, EastFire Conference, 2005*

RAY EDWARD (TED) HABERMANN

Education:

B.S. Geology, 1975, Beloit College
Ph.D. Geology, 1981 Univ. of Colorado

Employment History:

1981 - 1983	Research Associate, Univ. of Colorado, Boulder, Colorado
1983 - 1987	Assistant Professor, Georgia Institute of Technology
1987 - 1995	Assoc. Prof. Adjoint, University of Colorado
1987 – 2005	Fellow, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado
1995 - 1996	Assistant Director of GLOBE for Systems
1987 - Present	Geophysicist, National Geophysical Data Center Enterprise Data Systems Group Leader

Awards:

2007 Department of Commerce Bronze Medal.
2007 NOAA Administrator's Award.
2005 National Geophysical Data Center Director's Award.
2004 National Geophysical Data Center Staff Excellence Award.
2001 NOAATech 2000 – Best Advanced IT Tutorial.
1999 Department of Commerce Bronze Medal.
1995 National Geophysical Data Center Director's Award.
1995 Department of Commerce Silver Medal.

Committee Membership:

NOAA GOES-R System Engineering Integrated Project Team
NOAA GOES-R Archive Integrated Project Team
NOAA Integrated Ocean Observing System Integrated Project Team
NOAA Standards Working Group
NOAA Data Management Integration Team
NESDIS Archive Requirements Working Group
NESDIS Metadata Team

Recent Publications:

T. Habermann, Metadata for Data Understandability (2008). American Geophysical Union 2008 Joint Assembly.

T. Habermann, A. Milan (2007). Evolution of Metadata Standards: New Features in ISO 19115, American Geophysical Union 2007 Fall Meeting.

T. Habermann, J. Cartwright, C. Fox (2007). GIS: It's Not About the Map, American Geophysical Union 2007 Fall Meeting.

Narasimhan K. ('Sim') Larkin

USDA FS / PNW / AirFire
400 N. 34th Street, Suite 201
Seattle, WA 98103

Email: larkin@fs.fed.us
Phone: 206-732-7849

EDUCATION

Ph.D.	Climate Diagnostics (School of Oceanography) University of Washington, Seattle, Washington	2000
B.A.	Physics (w/High Honors) University of California, Berkeley, California	1991

HONORS

National Fire Plan Excellence in Research Award, 2005 (BlueSky Modeling Consortium)
NOAA PMEL Outstanding Scientific Paper Award, 1996
NDSEG & NSF Graduate Research Fellowship, 1993–1996
Phi Beta Kappa

PROFESSIONAL EXPERIENCE

2001-present	Research Physical Climatologist, USFS AirFire Team
2005	NATO Advanced Studies Institute, Gallipoli, Italy
2000-2001	Post-doctoral Fellow, JISAO, University of Washington
1997	NATO Advanced Studies Institute, Les Houches, France
1992-2000	Research Assistant, University of Washington

RECENT SELECT PRESENTATIONS

(136 total / 74 personally presented / 42 invited)

2007	7th Forest and Fire Meteorology Conference, Bar Harbor, Maine (conference co-chair)
2007	2nd Fire Behavior and Fuels Management Conf., San Destin, Florida (session asst. org.)
2007	Canadian Smoke Forecasting Workshop (invited), Edmonton, Alberta
2007	National Air Quality Conferences (invited), Orlando, Florida

SELECT REFEREED PUBLICATIONS

(36 total publications / 19 refereed)

O'Neill, S., **N.K. Larkin**, J. Hoadley, G. Mills, J.K. Vaughan, R. Draxler, M. Ruminski, and S.A. Ferguson (2008) "Real time smoke predictions" IUFRO invited book chapter (in press)

McKenzie, D., S.M. O'Neill, **N.K. Larkin**, and R.A. Norheim. (2006). "Integrating models to predict regional haze from wildland fire." *Ecological Modeling*, 199, 278-288.

Larkin N. K., and D. E. Harrison (2005). "On the definition of El Niño and associated seasonal average U.S. weather anomalies." *Geophys. Res. Lett.*, 32, L13705, doi:10.1029/2005GL022738.

Larkin N. K., D. E. Harrison (2005). "Global seasonal temperature and precipitation anomalies during El Niño autumn and winter." *Geophys. Res. Lett.*, 32, L16705, doi:10.1029/2005GL022860.

Larkin, N.K., and D.E. Harrison. (2002). "ENSO Warm (El Niño) and Cold (La Niña) event life cycles: ocean surface anomaly patterns, their symmetries, asymmetries, and implications." *J. Climate*, 15, 1118-1140.

Harrison, D.E., and **N.K. Larkin.** (1998). "Seasonal U.S. temperature and precipitation anomalies associated with El Niño: Historical results and comparison with 1997-98." *Geophys. Res. Lett.*, 25 (21), 3959-3962.

Larkin, N.K., and D.E. Harrison. (2001). "Tropical Pacific ENSO cold events, 1946-1995: SST, SLP and surface wind composite anomaly patterns." *J. Climate*, 14, 3904-3931.

Bret A. Schichtel

Biographic Sketch

National Park Service
Cooperative Institute for Research in the Atmosphere (CIRA)
Colorado State University
Fort Collins, CO 80523

e-mail: schichtel@cira.colostate.edu
Phone: (970) 491 - 8581
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Education

B.S. (Mechanical Engineering) Virginia Polytechnic Institute & State University, 1989
M.S. (Mechanical Engineering) Washington University, 1991
Sc. D. (Mechanical Engineering) Washington University, 1996

Employment History

2003-present	Physical Scientist, GS-13, Air Research Division, National Park Service, Fort Collins, CO
2000-2003	Research Scientist II, CIRA, Colorado State University.
1996-2000	Research Associate, Center for Air Pollution Impact and Trend Analysis (CAPITA), Washington U. St. Louis MO.

Selected Publications

Schichtel, B. A., W. C. Malm, G. Bench, S. Fallon, C. E. McDade, J. C. Chow and J. G. Watson. (2008) Fossil and Contemporary Fine Carbon Fractions at 12 Rural and Urban Sites in the United States. *J. Geophys. Res.*, **113**, D02311.

Pitchford, M., W. C. Malm, B. A. Schichtel, N. Kumar, D. Lowenthal J. L. Hand. (2007) Revised Algorithm for Estimating Light Extinction from IMPROVE Particle Speciation Data. . *JAWMA*, **57**: 1326-1336.

Gebhart K.A., B.A. Schichtel, M.G. Barna, W.C. Malm. (2006) Quantitative back-trajectory apportionment of sources of particulate sulfate at Big Bend National Park, TX. *Atm. Env.* **40** (16): 2823-2834.

Barna, M.G., B.A. Schichtel, K.A. Gebhart and W.C. Malm. (2006). Modeling regional sulfate during the BRAVO study: Part 2. Emission sensitivity simulations and source apportionment. *Atm. Env.* **40 (14)**: 2423-2435.

Schichtel, B. A., W. C. Malm, K. A. Gebhart, M. G. Barna, and E. M. Knipping (2006), A hybrid source apportionment model integrating measured data and air quality model results, *J. Geophys. Res.*, **111**, D07301, doi:10.1029/2005JD006238.

Schichtel, B.A., K.A. Gebhart, Barna, M.G., W.C. Malm (2006) Association of airmass transport patterns and particulate sulfur concentrations at Big Bend National Park, Texas. *Atm. Env.* **40 (5)**: 992-1006.

Schichtel, B.A., K.A. Gebhart, W.C. Malm, M.G. Barna. (2005) Reconciliation and interpretation of Big Bend National Park particulate sulfur source apportionment: Results from the Big Bend Regional Aerosol and Visibility Observational study - Part I. *JAWMA*, **55 (11)**: 1709-1725.

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Current Pending Support

Name: Rudolf B. Husar August 2008
Center for Air Pollution Impact and Trend Analysis, Washington University, St.Louis

Total of five months (42% of time)

SUPPORTING AGENCY AND AGENCY ACTIVE AWARD/PENDING PROPOSAL NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF COMM	TITLE OF PROJECT	PI
NASA Award 1322-59743	$1,524K	11/08/04-11/07/09	25 %	Application of ESE DATA and Tools to Particulate Air Quality Management	S. Falke/R. Husar
NASA thru Northrop Grumman Corp.	$60K	09/7/06-09/5/09	2 %	Sensor-Analysis-Model Interoperability Technology Suite (SAMITS)	S. Falke
EPA	$35K	07/11/07-07/11/08	5 %	Provide Exceptional Events Technical Guidance (Consulting PI)	R. Husar
EPA thru Sonoma Technology, Inc.	$12K	10/16/07-06/06/08	2%	Provide guidance on AirNOW International design, (Consulting PI)	T. Dye
NASA thru Baron Advanced Meteorological Systems	$188K	01/06/07-12/31/09	8%	Assimilating MODIS-derived Aerosol Optical Thickness into an Operational Air Quality Forecast Decision Support System, (Consulting PI)	J. McHenry

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